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## **Environmental-Based Experiential Learning Activities and Its Influence on Students' Knowledge, Critical Thinking, Attitude Towards the Environment, and Career Aspirations**

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ENVIRONMENTAL-BASED EXPERIENTIAL LEARNING ACTIVITIES AND ITS  
INFLUENCE ON STUDENTS' KNOWLEDGE, CRITICAL THINKING, ATTITUDE  
TOWARDS THE ENVIRONMENT, AND CAREER ASPIRATIONS

by

Veshell La'Shae Lewis

A Dissertation  
Submitted to the Graduate School  
the College of Arts and Sciences  
and the Center for Science and Mathematics Education  
at The University of Southern Mississippi  
in Partial Fulfillment of the Requirements  
for the Degree of Doctor of Philosophy

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## ABSTRACT

Modern advancements in industrialization and globalization are thought to be responsible for the present ecological issues facing the world (Sumen, 2016). Many countries, including the United States, emphasize the importance of increasing environmental literacy within the community and schools (Roth, 1992; Scholz, 2011; Sumen, 2016). It has been suggested that environmental education be taught at all educational levels to increase environmental literacy (Sumen, 2016). The implementation of environmental-based experiential education within the traditional curriculum has proven successful for various educational institutions. Therefore, the implementation of environmental-based experiential learning activities in Mississippi educational institutions may contribute to the increase of scientifically literate students prepared to compete for degrees and careers in STEM.

The purpose of this study was to determine the effectiveness of environmentally-based experiential learning activities, on students' knowledge acquisition, critical thinking, and attitudes toward the environment and career aspirations. The study relied heavily on the Global Learning and Observations to Benefit the Environment (GLOBE) program to accomplish set goals. The study was quantitatively analyzed based on the scores of the Environmental Knowledge Assessment, Cornell Critical Thinking Test, Children's Environmental Attitude and Knowledge Scale (CHEAKS) Survey, and Career Aspirations Survey. A mixed model analysis of variance (ANOVA) design was used during this study to compare the differences in gain scores of the students who experienced the environmentally-based experiential learning activities during instruction and the student who only experienced traditional instruction. It was determined that the

incorporation of environmentally-based experiential learning activities supported by GLOBE activities and Kolb's experiential learning model exercises proved to play a significant role increasing student knowledge acquisition and critical thinking skills. However, these activities did not prove to be effective in improving students' attitude toward the environment to consider being more involved in the environmental sustainability or improving students' career aspirations towards a career in STEM.

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I would also like to extend my gratitude to all individuals and organizations that assisted me in my efforts.

## DEDICATION

This dissertation is dedicated to my family whom I love dearly. To my husband, Thomas Sr., who demonstrated continuous love, patience, and encouragement throughout this journey. I could not have completed this task without your support. To my wonderful children, Talia and Thomas Jr., for your patience and understanding. I hope my actions inspire you to always strive to be the best that you can be.

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## LIST OF ABBREVIATIONS

<i>CHEAKS</i>	Children’s Environmental Attitude and Knowledge Scale
<i>DDT</i>	Dichlorodiphenyltrichloroethane
<i>EE</i>	Environmental Education
<i>EPA</i>	Environmental Protection Agency
<i>GLOBE</i>	Global Learning and Observations to Benefit the Environment
<i>NAAEE</i>	National American Association of Environmental Education
<i>NAEP</i>	National Assessment of Education Progress
<i>NCES</i>	National Center for Education Statistics
<i>PALS</i>	Performance Assessment Links in Science
<i>PISA</i>	Program for International Student Assessment
<i>SCORE</i>	South Carolina Oyster Restoration and Enhancement Program
<i>STEM</i>	Science, Technology, Engineering and Mathematics

## CHAPTER I - INTRODUCTION

The emergence of the environmental evolution of the 1960s began with recognizing conservation issues, such as air and water pollution, wildlife endangerment, tree reduction, and even human public health issues related to pesticides and toxic wastes, stemming from human actions. In 1962, the harmful impact of environmental pollution resulting from the use of chemicals, such as DDT on the natural environment and populations of animals and humans, was revealed in the book *Silent Spring* written by the environmentalist, Rachel Carson (Dunlap & Mertig, 1991). The consequences of DDT affected diverse populations of animals due to the consumption of contaminated food sources. For example, contaminated fish consumed by the bald eagle resulted in its inability to produce strong, thickened shells, which led to a decline in their population (Croco, Shuttleworth & Chandler, 2016; Gordon, 2012; US Fish & Wildlife Service, 2016;).

In 1969, the Santa Barbara oil spill occurred off the coast of Southern California in which 200,000 gallons of crude oil bubbled to the surface from beneath the earth covering a stretch of 800 square miles with dramatic impact on marine and aerial populations. According to the Santa Barbara Wildlife Care Network, many dolphins perished from massive lung hemorrhages, as a consequence of the crude oil obstructing their blowhole (Santa Barbara Wildlife Care Network, 2016). Seabirds, such as grebes, suffered from hypothermia caused by the impairment of their waterproof feathers from overexposure to oil, which can ultimately lead to death. Seabirds also died from internal organ damage resulting from the preening of oily feathers (International Bird Rescue, 2016). It was estimated that thousands of sea animals and nearly 3,700 seabirds died as a

result of the Santa Barbara oil spill of 1969 (Hardy, 2005).

Environmental issues publicized in Rachel Carson's *Silent Spring* and the Santa Barbara oil spill of 1969 led to the creation and implementation of legislation to regulate pollution and protect natural resources (Gordon, 2012). Successful legislation led to the enactment of the following environmental laws: The Clean Air Act (1963), Wilderness Act (1964), Water Quality Act (1965), National Scenic Trails Act (1968), Resource Conservation and Recovery Act (1970), Federal Environmental Pesticide Control Act (1972), Endangered Species Act (1973), Toxic Substance Control Act (1976), and Alaska National Interest Lands Conservation Act (1980) (NOAA, 2012; Walls, 2014).

With the increase in environmental issues, the government officially initiated an in-depth examination of these concerns resulting in the creation and implementation of the National Environmental Education Act of 1970. Under President Richard Nixon, the United States the first country to pass legislation regarding environmental education (Lynch, 2001). The goal of the National Environmental Education Act was to improve natural and human-made environments through education and enrichment in decision-making. In the 1990s, Congress included environmental education to the U.S.

Environmental Education through the National Education Act with the intention of increasing environmental literacy, which is defined as the capacity to demonstrate knowledge and understanding of the environmental systems, and the ability to improve the conditions affecting it through the implementation of environmental education curricula and teacher training (McCrea, 2006; National Education Advisory Council, 1996). Today, state and local educators face the real challenge of creating and teaching effective environmental lessons interconnected to traditional K-12 curricula (Tuten,

1997).

Organizations such as the North American Association for Environmental Education (NAAEE), provide state officials and educators with information about environmental education and how to implement it within their curriculum. According to the NAAEE (2010), environmental education provides the necessary science content to children and adults and teaches them how to research and “investigate their environment and to make intelligent, informed decisions about how they can take care of it”. The NAAEE promotes environmental education in traditional classrooms, community workshops, and informal education settings such as zoos, parks, and nature centers (NAAEE, 2010). Within these environments, students will learn how the study of the environment incorporates various subject areas such as biology, mathematics, history, language, arts, and chemistry. NAAEE (2010) suggests that environmental education should be taught in an organized sequence reflective of state and national learning standards to turn out academically successful and environmentally literate students.

Koutsoukos, Fragoulis, and Valkanos (2015) suggested the inclusion of experiential learning methods when constructing an environmental education-based curriculum. Experiential learning is a process where participants learn through experience (I.e. learning by doing). This philosophy is based on three assumptions: 1) individuals learn best through personal experience; 2) knowledge discovered by the individual can significantly impact their behavior; and 3) individuals are more prone to set high learning goals when given freedom (Ord & Leather, 2011; Smith, 1980). Research supports the idea that experiential learning methods applied to environmental education encourage critical thinking, problem-solving skills, social skills, as well as teacher and student



collaboration (Arslan, 2012; Koutsoukos et al., 2015). Research also supports the establishment of a connection between environmental education and experiential learning permits that promotes active involvement of students in their own learning experience (Koutsoukos et al., 2015; Markaki, 2014; Rickinson & Lundholm, 2008; Sandoval & Bell, 2004).

### Statement of Problem

Modern advancements in industrialization and globalization are thought to be responsible for the present ecological issues facing the world (Sumen, 2016). Many countries, including the United States, emphasize the importance of increasing environmental literacy within the community and schools (Sumen, 2016; Roth, 1992; Scholz, 2011). Environmentally literate individuals are more knowledgeable, conscious, and concerned about the health of Earth systems and how human actions affect these systems (Sumen, 2016; Teksoz, Sahin, & Ertepinar, 2010). It has been suggested that environmental education be taught at all educational levels to increase environmental literacy (Sumen, 2016). Implementing environmental education from preschool to college will help promote and pass on environmentally supportive values and attitudes from one generation to the next (Mutisya, Kipgetich, & Rono, 2013). Therefore, there is thus a need to encourage teachers and students to value environmentally literacy with problem-solving skills. According to Wagner (2008), 21<sup>st</sup>-century students should not be required to only memorize existing knowledge but to generate new knowledge and apply this knowledge to solving problems. Wagner (2008) went further to identify seven skills that every 21<sup>st</sup>-century student should possess:

- 1) Critical thinking and problem-solving;

- 2) Collaboration and leadership;
- 3) Agility and adaptability;
- 4) Initiative and entrepreneurialism;
- 5) Effective oral and written communication;
- 6) Accessing and analyzing information; and
- 7) Curiosity and imagination (pp. 20-25)

Science, Technology, Engineering, and Math (STEM) programs are an integrated educational approach that enables students in the four specific disciplines of science, technology, engineering and mathematics that aid in the cultivation of 21<sup>st</sup> century skill, necessary to research and develop solutions to environmental issues we face currently and in the future. According to Sahin, Ayar, and Adiguzel (2014), teaching the concepts of application and integration of science, technology, engineering, and mathematics furthermore fosters a STEM-literate society capable of achieving and maintaining scientific and economic leadership.

Despite the importance of STEM, the STEM Advantage (2013) reported that fewer than half of America's college students pursue a degree in the STEM field. This could be attributed to the lack of student readiness for the rigors of academic challenges in college, especially within the science and mathematics disciplines. The National Math and Science Initiative Organization (2012) reported that fewer than half of America's high school students are prepared for college-level science and mathematics (p.1). In 2013, the largest international comparative education corporation, the Program for International Student Assessment (PISA) measured 15-year-old students' mathematics, reading, and science literacy in more than 70 countries and educational jurisdictions and

concluded that the United States' performance on the science literacy assessment did not qualify to rank within the top 25 countries. However, PISA (2013) recognized Connecticut, Florida, and Massachusetts as the three states within the United States educational systems in which high school students' performance was among the best internationally. While a few states receive international recognition for outstanding academic performance, some states have acquired a national reputation for their inability to perform at or above the national level (PISA, 2013).

According to the National Assessment of Educational Progress (NAEP), a nationally recognized education "report card", known for its continuous assessment of what American students know and can do, Mississippi students lead in national gains with 4<sup>th</sup> grade mathematics and reading proficiency increases of 21% to 30%, and 8<sup>th</sup> grade mathematics and reading proficiency increases of 20% to 22% (MDE, 2015). Despite the national gains in fourth and eighth grade reading and mathematics, Mississippi's 8<sup>th</sup> grade science scores show little progression with no significant proficiency gains (NAEP, 2015). In spite of proficiency gains, when compared to other states, the 2015 NAEP scores for Mississippi show a low-performance ranking of 47 out of 52 for mathematics among fourth grade students, and low-performance ranking of 49 out of 52 for mathematics among eighth grade students (NAEP, 2015). In addition, Mississippi's science 2011 NAEP's scores also show a low-performance ranking of 47 out of 52 for science among fourth and eighth grade students nationwide. During the 2013-2014 school year, only 44% of eighth graders were deemed proficient on the Mississippi Science Test (NAEP, 2015). In the same school year, only 78% of high school students passed the Biology Subject Area Testing Program, 2nd Edition (SATP2)

test with only 51% being proficient (Mississippi Department of Education, 2015). In addition, Mississippi currently holds the national ranking of 43 for high school graduation rate which is defined as the number of students who graduate from a regular school within four years of starting the 9th grade (America's Health Rankings, 2015 and Change the Equation, 2015). Of these high school graduates, only 24.8% earn a science, technology, engineering, or mathematics college degree (Change the Equation, 2015). According to Change the Equation (2015), Mississippi STEM-related jobs will increase by 15% with a median earning of \$29.99 an hour and will require a two or four-year college degree. With the anticipated increase in STEM jobs and the shortage of educated individuals within this field, Mississippi will have difficulties filling job vacancies in areas such as healthcare, engineering, manufacturing, and energy technology.

### Significance of the Study

According to Education Week Quality Counts (2016), education in Mississippi results in the inability to produce scores that reflect K-12 achievement, especially within the sciences and mathematics (p.1). Mississippi's students' inability to advance academically could ultimately result in their inability to compete for degrees and careers in different fields, especially STEM careers. Ultimately, this results in fewer STEM professionals who can assess and work on solutions to environmental problems. The Atlantic (2016) reported that Mississippi would have over 46,000 STEM jobs available by the year 2018 and these jobs will require scientifically literate individuals with two to four-year STEM degrees. So, in terms of STEM jobs, there is a positive outlook for the state of Mississippi, but filling those job vacancies with the right candidates will be a challenge. According to Steve Suitts, Vice President of Southern Education Foundation,

the only way for that economic gap in Mississippi to close is for young people to get better-paid jobs. Those better-paid jobs are going to be in the STEM fields (Mader, 2013).

The implementation of environmental-based experiential education within the traditional curriculum has proven successful for various educational institutions. Research has shown that environmental education with the application of experiential teaching techniques has a positive impact on student knowledge, attitude towards the environment, critical thinking skills, and interest in STEM careers (Arslan, 2012; Lieberman, Hoody, & Lieberman, 2000). Therefore, the implementation of environmental-based experiential education in Mississippi educational institutions may contribute to the increase of scientifically literate students prepared to compete for degrees and careers in STEM.

#### Purpose of Study

High academic performance ranking states, such as Connecticut, Florida, and Massachusetts, are actively integrating high quality environmental education and experiential learning across the Pre-K-12 curriculum to shore up their students' academic performance (CT State Department of Education, 2015; League of Environmental Educators in Florida (LEEF), 2016; Miner & Klein, 2016; UMass Donahue Institute, 2014). Mississippi, on the other hand, is not faring very well in this area; therefore, the purpose of this study was to determine the effectiveness of environmentally-based experiential learning activities, on students' knowledge acquisition, critical thinking, and attitudes toward the environment and career aspirations. The study relied heavily on the Global Learning and Observations to Benefit the Environment (GLOBE) program to

accomplish set goals. GLOBE is an international science and education program that encourages students and other learners to take part in active data collection and the scientific process to enhance our understanding of the earth system and the global environment. GLOBE is jointly sponsored by U.S. National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF), with support from the National Oceanic and Atmospheric Administration (NOAA) and Department of State (GLOBE, 2016).

### Research Questions

This study addressed the following research questions:

1. What influence does environmental-based experiential learning activities have on knowledge acquisition among students, based on the Environmental Knowledge Assessment score?
2. What influence does environmental-based experiential learning activities have on students' critical thinking, based on the Cornell Critical Thinking Test Level X score?
3. What influence does environmental-based experiential learning activities have on students' attitude toward the environment, based on the Children's Environmental Attitude and Knowledge Scale score?
4. What influence does environmental-based experiential learning activities have on students' career aspirations, based on the Career Interest Survey (STEM-CIS) score?

## Theoretical Framework

The theoretical framework that guided this study was ‘experiential learning’ which is a theory developed and advocated by educational scholars such as Kurt Lewin (1946), Jean Piaget (1936), and John Dewey (1938). Experiential learning is defined as a process in which knowledge is created through experience (Kolb, 1984). A current education expert, David Kolb (1984), supports the idea of experiential learning; however, the learning approach neglects major components of the learning cycle. As a result, he created the Kolb’s Experiential Learning Model, which allows students to actively participate in their own learning. The model consists of four major phases: 1) concrete experience; 2) reflective observation; 3) abstract conceptualization; and 4) active experimentation. The concrete experience phase requires students to engage actively in a hands-on activity. The sequential phase, reflective observation requires that the students reflect on the results of the activity in which he or she was engaged. The implications of the results are examined during the next step called abstract experimentation. Lastly, the active experimentation phase requires the students to determine what he or she would do differently if given the opportunity to repeat the activity (Kolb, 1984). For the purpose of this study, the following elements of the revised experiential learning framework designed by Kolb (1984) guided this study.

## Assumptions

1. It was assumed that the teacher participants in this study utilized the GLOBE protocols as directed during GLOBE training sessions.
2. It was assumed that the student participants in this study answered the survey questions and assessment questions honestly and to the best of their abilities.

## Limitations of the Study

The following limitations applied to this study:

1. Only one school district in Mississippi participated in the study.
2. Only surveyed and assessed middle school students whose parents allowed them to participate.
3. Only included middle school students enrolled in a science course.
4. Only included science teachers who completed the GLOBE training session.
5. Only included students with a GLOBE-trained teacher.

## Definitions of Terms

*Experiential learning.* A learning process that creates knowledge through the transformation of experiences, resulting in an alteration in thinking and behavior (Kolb, 1984; Rizk, 2011).

*Environmental Awareness.* To display concern and sensitivity towards the environment (Le Hebel, Montpied & Fontanieu, 2014).

*Environmental Knowledge.* A basic understanding of environmental issues and the ability to evaluate their impact on the environment and society (Chekima, Chekima, Syed Khalid Wafa, Igau, & Sondoh Jr, 2016).

*Attitude towards environment.* Values, feelings of concern, and motivations towards the participation of environmental improvement and protection (Eilam & Trop, 2012).

*Environmental education.* A process that helps individuals become more knowledgeable and aware of environmental issues, and allows them to develop the skills necessary to address environmental issues (NAAEE, 2016).



*Environmental responsible behavior.* Corrective actions taken by an individual to improve environmental circumstances (Giuseffi, 2011, Sivek & Hungerford, 1990).

## CHAPTER II – LITERATURE REVIEW

The purpose of this study was to gain an understanding of the effects of environmental-based experiential learning activities, with the aid of the GLOBE program, on students' knowledge acquisition, critical thinking, and students' attitude toward the environment, skill mastery and career aspirations. Literature derived from various sources aided in the construction of the context for this study. The literature review includes a brief history of environmental education and experiential education, their current role in education, and research associated with student achievement, attitude, and future career plans.

### Brief History of Environmental Education and Experiential Learning

Environmental Education is fundamental to our everyday lives -- it promotes human health, quality education, sustainable development, employment, and protection of America's culture (National Environmental Education Advisory Council, 1996). The foundation of modern environment education was initiated with the passing of the National Environmental Policy of 1969, which encouraged the promotion of harmony between humans and the environment. In 1970, the U.S congress passed the National Environmental Education Act, which was aimed at promoting environmental education. The National Environmental Education Act is responsible for the creation of the National Advisory Council and Office of Environmental Education in the U.S. Dept. of Health, Education and Welfare (McCrea, 2006). Twenty years after, congress passed the National Environmental Education Act of 1990, with the goal of promoting environmental education as educational activities and training activities involving elementary, secondary, and postsecondary students, as such terms are defined in the State (EPA,

1990). According to the National Environmental Education Advisory Council, environmental education is defined as a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address these challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (National Environmental Education Advisory, 1996; UNESCO, 1978). The National Environmental Education Advisory Council (1996) established the following goals for environmental education within the U.S:

1) provide sufficient knowledge to produce good environmental decisions; 2) develop the ability to understand how human behaviors influence the environment; 3) develop the ability to investigate environmental issues and generate practical solutions; 4) acquire the skills to take positive actions to resolve environmental issues.

Modern environment education is indebted to past educational philosophers, such as Jean-Jacques Rousseau (1762), Johann Henrich Pestalozzi (1801), and Friedrich Frobel (1837). Jean-Jacques Rousseau, a 17<sup>th</sup> century French/Swiss writer, and a philosopher with political influence advocated for the creation of educational programs that aimed to develop “free-thinking” productive, moral citizens (Smith, Knapp, Seaman & Pace, 2011). Rousseau argued that instruction should reflect everyday experiences of the students, which led to the promotion of natural education. The principles of natural education require that the teacher serves as a guide and a provider of ‘natural experiences and natural objects’ and permit the student to explore his or her interest (Smith et al., 2011). Rousseau stressed that learning takes place when the student is permitted to follow their curiosity:

If he goes wrong, do not correct his errors. Say nothing till he sees them and corrects them himself; or at most, arrange some practical situation which will make him realize things personally. If he never made mistakes he would never learn properly (Rousseau, 1956, p.76).

As a writer, Rousseau contributed to education with the publication of *Emile* in 1762 a book that emphasized the implementation of an educational method based on various stages of human development (Armitage, 2004). Many educators and theorists took interest in the thoughts of Rousseau expressed in *Emile*.

Johann Henrich Pestalozzi, a Swiss education reformer, was so captivated by Rousseau's *Emile* that he used the book as a guide to instruct his son (Smith et al., 2011). Influenced by Rousseau's philosophy of natural education, Pestalozzi stressed the importance of "sense perceptions" and "object lessons" within the daily instruction to refine students' sensory awareness (Smith et al., 2011). Pestalozzi elaborated upon his child-centered teaching philosophy with the publication of *How Gertrude Teaches Her Children* in 1801. According to McKenna (2012), the manuscript outlined the most important points: 1) children possess a sacred personality; 2) children are not miniature adults; 3) educators need to nurture the children's natural development; and 4) the growth of a child requires movement and spontaneity. The child-centered teaching philosophy of Pestalozzi inspired educators, especially Friedrich Frobel, a past German student of Pestalozzi. Frobel believed children should be taught in a manner in which creativity and play are advocated (Russo, 2012). In 1837, Frobel created the first kindergarten system based on the principle that materials were organized into two categories: gifts and occupations. The objects with a fixed shape were considered gifts (items such as blocks,

balls, and sticks), while occupations were malleable things such as clay, sewing, and string along with games, songs, and play, contributes to the development physical and motor skills (Field, 2000). According to Field (2000), the goals of Froebel's kindergarten include the incorporation of physical activity, nurturing of creativity, encouraging the exploration of ideas, and development of sensory awareness and physical dexterity. Jean-Jacques Rousseau, Johann Henrich Pestalozzi, Friedrich Frobel, and other significant philosophers' contribution to the development of environment education led to the establishment of the progressive education era and nature study.

In the 1890s, the Progressive Education Movement inspired by philosophers, such as Kurt Hahn, Paulo Freire, and John Dewey, was started as an alternative teaching practice that emphasized students' individual growth and development through increased freedom in the classroom. Kurt Hahn, a 20<sup>th</sup>-century German educator, advocated that a full education requires the utilization of outdoor recreation such as land or sea expeditions (Pace, 2011). Kurt Hahn (1960) stated that, "Experience has taught us that expeditions can greatly contribute towards building strength of character" (p. 5). In 1941, Hahn contributed to the birth of the first Outward Bound School in Aberdovey, Wales. Hahn's values and ideas as well as those of other educators are currently reflected in 30 international schools and 160 schools in the United States (Hansford, 2015). Past and current schools have established Hahn's inspired principles (Thorton Creek School District, 2016) as follows:

- 1) *The primacy of self-discovery.* Learning happens best with emotion, challenge and the requisite support. People discover their abilities, values, passions, and responsibilities in situations that offer adventure and the

unexpected. In Expeditionary Learning schools, students undertake tasks that require perseverance, fitness, craftsmanship, imagination, self-discipline, and significant achievement. A teacher's primary task is to help students overcome their fears and discover they can do more than they think they can.

- 2) *The having of wonderful ideas.* Teaching in Expeditionary Learning schools fosters curiosity about the world by creating learning situations that provide something important to think about, time to experiment, and time to make sense of what is being observed.

*The responsibility for learning.* Learning is both a personal process of discovery and a social activity. It could be done individually or as part of a group. Every aspect of an Expeditionary Learning school encourages both children and adults to become increasingly responsible for directing their own personal and collective learning.

- 3) *Empathy and caring.* Learning is fostered best in communities where students' and teachers' ideas are respected and where there is mutual trust. Learning groups are small in Expeditionary Learning schools, with a caring adult looking after the progress and acting as an advocate for each child. Older students mentor younger ones, and students feel physically and emotionally safe.
- 4) *Success and failure.* Every student needs to be successful if they are to build the confidence and capacity to take risks and meet increasingly difficult challenges. But it is also important for students to learn from their failures,

to persevere when things are hard, and to learn to turn their failures into opportunities.

- 5) *Collaboration and competition.* Individual development and group development are integrated so that the value of friendship, trust, and group action is clear. Students are encouraged to compete not against each other but with their own personal best and with rigorous standards of excellence.
- 6) *Diversity and inclusion.* Both diversity and inclusion increase the richness of ideas, creative power, problem-solving ability, and respect for others. In Expeditionary Learning schools, students investigate and value their different histories and talents as well as those of other communities or cultures. Learning groups are heterogeneous in various schools.
- 8) *The natural world.* Direct respectful relationship with the natural world refreshes the human spirit teaching the important ideas of recurring cycles and cause and effect. Students learn to become stewards of the earth and of future generations.
- 9) *Solitude and reflection.* Students and teachers need time alone to explore their own thoughts, make their own connections, and create their own ideas. They also need time to exchange their reflections with others.
- 10) *Service and compassion.* We are a crew, not passengers. Students and teachers are strengthened by acts of consequential service to others, and one of an Expeditionary Learning school's primary functions is to prepare students with the attitudes and skills to learn from and be of service to others.

Paulo Freire, a Brazilian educator, emphasized the critical value of praxis on experiential learning (Breunig, 2011). Praxis is defined as a process that requires reflection and action, which should eventually lead to transformation or liberation, thus creating a better world (Sisimwo, Caren, & Ahmed, 2014). Freire argues that praxis starts with an abstract idea or experience. Breunig (2011) states, "If a student starts with an experience, the experience can be enhanced by reflection and by encouraging the student to form concepts and generalizations" (p. 60). In 1970, Freire published, "Pedagogy of the Oppressed" a book that presented an educational approach to transforming oppressive world structures to more equitable structures through actions and reflections (Saxon, 2011).

Paulo Freire believed that the problem-posing method of education would aid in transformation or liberation. The problem-posing method of education is a practice that values the experiences of students and teacher-student engagement. The engagement of the teacher and student results in knowledge exchange and learning, resulting in transformation. He further argued that the experience obtained by the teacher should not be the only experience valued (Breunig, 2011).

John Dewey, Father of the Progressive Movement, was an American philosopher and educational reformer recognized as a major contributor to the Progressive-Education Movement from the early 1890s to the 1950s. The movement represented a phase in which American education emphasized the recognition of children as social beings and the need to support their individual growth and development, this led to the acknowledgment of the necessary connection between education and life to establish a more meaningful school curriculum (Cremin, 1959). John Dewey stated that the gap



existing between education and life could be united by the concept of “learning by doing” (Cremin, 1959). Dewey (1938) claimed, “an experience is always what it is because of a transaction taking place between an individual and his environment” (p.123). Dewey proposed that the concept of experience would always consist of active and passive components. Experience is understood as trying when one is active. The continuation of the experience is viewed as passive. The connection of active and passive components contributes immensely to the value of the experience. Learning from an experience entails the linkage of what we do or try and results from the environment (Dewey, 1912; Dewey & Rogers, 2012). The environment is defined by the interaction of various conditions with personal needs, desires, purposes and capacities that influence the experience (Dewey, 1938). Dewey also emphasized the importance of realizing that all experiences are not genuine and equally educative. An educative experience is differentiated from a non-educative experience based on its ability to positively or negatively influence future experiences (Na & Song, 2014). Educative experiences facilitate learning that must be enriched and organized for the progression of learning. Based on this, Dewey was compelled to consider pedagogical methods and processes (Mayer, 2008). He, later expressed that instructors can aid in the progressive development of what is experienced, only if they begin instruction taking into consideration what the students have already experienced (Na & Song, 2014).

Dewey’s support for the concept of the experience is credited to past philosophers, such as Piaget and Lewin. Jean Piaget, a Swiss developmental psychologist, and philosopher advocated the construction of knowledge through experience. Piaget’s work on the developmental stages of cognitive growth stressed the

importance of active learning and concrete experiences (Kraft & Kielsmeier, 1995). He also described how mental development impacts the process of learning. Piaget's theory of development explains the four major contributors that influence mental development: 1) physical maturation; 2) experience that involves handling, moving, and thinking about concrete objects; 3) social interaction; and 4) equilibration which results from the cohesion of the other factors (Kraft & Kielsmeier, 1995). Overall, the theory of development implies that both adults and children need concrete experiences to aid in the process of learning and physical knowledge.

The concept of experience was also supported by Kurt Lewin, an American psychologist, responsible for defining and developing action research. The idea of action research, which stemmed from a controlled laboratory environment, described as a cycling back and forth between ever deepening surveillance of the problem situation and a series of research-informed action experiments (Dickens & Watkins, 1999). The process of action research consists of the following steps: 1) identify the problem within the context; 2) collect data related to the context; 3) analyze the data collected, and 4) generate possible solutions to the problem (Dickens & Watkins, 1999). Both action research and traditional science share the goal of creating knowledge however, they differ in purpose and execution. Action research works to make scientific discoveries in addition to resolving practical problems, while traditional science does not attempt to solve problems (Cohen & Manion, 1980) but to authenticate old facts and uncover new facts.

By the late 19<sup>th</sup> and early 20<sup>th</sup> century, the nature study teaching approach had gained popularity within schools in the United States. Nature study is a teaching

pedagogy that utilizes the students' curiosity for the natural world to develop explorations that incorporate scientific process skills (McComas, 2005). It builds students' interest with the integration of the inquiry approach, a multifaceted activity that requires the learner to make observations, formulate questions, develop investigations, analyze and interpret results, and establish explanations or conclusions (McComas, 2005; NRC, 1999). According to McComas (2005), in nature study, the first science framework requires the instruction to address *what* science is and *how* it should be taught. The most prominent supporters of nature study instruction were Anna Botsford Comstock, Aldo Leopold, and Rachel Carson.

Anna Botsford Comstock is an American conservationist and well-accomplished scientist known for award-winning engravings and authoring/illustrating numerous books including *Ways of the Six-Footed* (1903), *How to Keep Bees* (1905), *The Handbook of Nature Study* (1911), *The Pet Book* (1914), and *Trees at Leisure* (1916). In addition, Comstock served as a progressive educator responsible for leading the nature-study movement with her teachings of nature-study through elementary materials for teachers using the publication *Handbook of Nature Study* in 1911. An inspired past student of Liberty Hyde Bailey, Comstock developed a nature-study philosophy detailing how it should be taught in schools since she often worked directly with teachers (Smith et al., 2011; Woodhouse & Wells, 2011). She believed that nature study should be taught in a manner that would capture student interest and provide opportunities for direct observations and experimentations to take place. Comstock wrote in the book *Handbook of Nature Study*, Make the lessons an investigation and make the pupils feel like investigators (Comstock, 2010; Smith et al., 2011; Woodhouse & Wells, 2011).

Comstock's nature study based teaching pedagogy remains a popular and necessary tool in the classrooms of many educators.

Aldo Leopold, an American conservationist and founder of wildlife management, voiced the importance of connecting to the environment through publications including *Game Management* (1933) and *A Sand County Almanac and Sketches Here and There* (1949) (Aldo Leopold Foundation, 2016). In addition, Leopold served as the first Professor of Wildlife Management at the University of Wisconsin where he taught forest and wildlife conservation and management. As a professor, he focused on teaching students to see the land, understand what is seen, and enjoy the understanding attained (Meine, 1991; Simpson, 2009; Smith et al., 2011). As a citizen, he advocated 'land ethics' which emphasized understanding the land and developing respect for the land's wisdom and beauty, and recognition of individual relationships to the land. Leopold felt that educated individuals would serve as great stewards since they understand how the ecological factors could affect them personally (Gundersen & Makinen, 2009). Smith and Knapp (2011) affirmed, "Teaching in the spirit of the land ethic means that educational programming takes every reasonable opportunity to move both the individual and society toward environmental consciousness" (p. 121)

Rachel Carson, an American conservationist, and biologist is recognized for steering the environmental movement with the publication of *Silent Spring* in 1962. At a young age, Carson was taught how to observe and record happenings in nature and even introduced to Anna Botsford Comstock's, *Handbook of Nature Study* under the guidance of her family (Crocco, Shuttleworth, & Chandler, 2016). Later in life, Carson obtained a biology degree from John Hopkins University and was hired as a writer for the U.S. Fish

and Wildlife Service. After the publication of her bestseller books: *The Sea Around Us* (1951) and *The Edge of the Sea*, (1955), she became a well-respected independent nature writer (Kowalski, 2016). Carson's dedication to the understanding of the environment and its interconnectedness to all life forms motivated her to research the environmental consequences of the usage of pesticides, such as DDT (dichlorodiphenyltrichloroethane) (Crocco et al., 2016). Her research led to the publication of *Silent Spring* in 1962, uncovering the dangers of the accumulation of DDT and other pesticides within the ecosystem through the soil, water, and living things. The endangerment of the bald eagle, due to its thin-shelled eggs, was one major threat mentioned in *Silent Spring*. Carson's work contributed to the establishment of the Environmental Protection Agency to regulate the use of various synthetic chemicals (Lear, 1998). Carson's appreciation for nature and desire to educate contributed to her ability to write vividly about natural occurrences (Warren & Wapotich, 2011). Dedicated to environmental education, she published an article, *Help Your Child to Wonder* that encouraged parents to explore with their children (Warren & Wapotich, 2011).

### Experiential Learning in the Classroom

Experiential education is an instructional approach based on the idea that learning occurs through experience or simply by doing (Coffey, 2009; Lewis & Williams, 1994). This teaching approach requires the active participation of students through the application of hands-on opportunities that develop connections to the students' lives (Coffey, 2009). This process encourages the students to deepen their understanding of the nature of knowing (Hutchings & Wutzdorff, 1988). Therefore, the process of learning is impacted by the ability to connect learning to the students' concrete experiences

(Hutchings & Wutzdorff, 1988). According to Herbert (1996), experiential learning within a classroom environment requires the student to actively participate in his or her learning, while the teacher serves as a guide and resource. A deeper understanding of experiential learning is attributable to the exploration of five factors: reality, risk, responsibility, predictability, and reflection. The perception of reality within the experiential learning classroom is displayed in activities such as demonstrations, modeling, handouts based on real life, and whole-class experience (Herbert, 1996). The student's experience of reality predicts or indicates his or her own sense of risk and uncertainty. Risk can be understood as the place in which the student may feel uncomfortable (Herbert, 1996); therefore, the classroom environment will greatly influence the level of risk by the amount of trust and support offered by the teacher and students. Once the student is willing to take a risk then he or she will have the confidence to take responsibility for his or her learning (Herbert, 1996).

Experiential learning gives the student the ability and opportunity to be involved in decisions leading to their experience. The role of the teacher is simply a guide, and the students become decision-makers. This scenario makes it difficult to predict specific outcomes, which requires the teacher to effectively plan (Herbert, 1996). Despite the inability to predict specific outcomes, experiential learning allows students to learn from their experiences through reflection. Reflection enables the students to think about what is happening and their role in the process. It can take place among individuals or in a group setting, which can be practiced verbally or nonverbally (Herbert, 1996; Kraft & Kielsmeier, 1995).

The successful execution of experiential learning requires strategies that foster

and enhance the process. Herbert (1996) explained that ‘Active’ does not translate into ‘experiential’. Therefore, experiential activities must show that students’ ultimately exhibit learning through assessment. Tomasello, Kruger, and Ratner (1993) state that learning takes place in three various forms: imitative learning, instructed learning, and collaborative learning. Imitative learning is a process in which the learner learns instructor modeling. Instructed learning is the method in which the instructor directs instruction as in a traditional classroom. Collaborative learning is a practice in which learning takes place when information is shared between the teacher and student (MacIsaac & Jackson, 1994).

Experiential activities both in-class and field experiences enhance concept development. In-class experiences are activities conducted within a classroom environment (Lee & Caffarella, 1994). In-class experiences, coupled with experiential learning activities, foster enrichment of knowledge. Experiential learning in-class activities include group discussion, listening group, games, poster presentations, debate, journaling, and case-study research. In a group discussion, information or ideas are exchanged among a minimum of five persons. Learners in a group listen, observe, and discuss a designated section of a speech or similar source (Lee & Caffarella, 1994). Games are an instructional technique that enables learners to practice specific skills such as critical thinking and creative, while enhancing their competitive and cooperative skills. Poster creation and presentation is an instructional method based on a specific topic while a debate is described as a technique in which the learner expresses his or her views on a specific topic to others. Journaling, on the other hand, is a useful technique since it permits the learner the opportunity to record his or her experiences. Case-study research

is a practice in which the learner observes and analyzes a record of research, regarding a specific situation. Field experiences are regarded as instructional activities that are conducted in real-world environments (Jackson & Rosenberg 1990). Field experiences coupled with in-class experiential learning activities support knowledge synthesis and self-directed learning (Lee & Caffarella, 1994).

Experiential learning includes activities like coaching, internship, mentoring, and analysis of practice. Coaching is a technique in which the learner experiences a one-on-one learning by demonstrations conducted by an expert in the field. Internships facilitate learning through practice experience. Mentoring supports the professional and personal growth of the learner through the guidance of experienced individuals (Lee & Caffarella, 1994). Lastly, analysis of practice is a technique that involves the examination of real-world contexts to gain an understanding of how to perform specific tasks or how to react to various situations if and when they occur (Jackson & Rosenberg, 1990).

The most modernized modified form of experiential learning was inspired by the works of Jean Piaget, John Dewey, and other philosophers including David Kolb, an American educational theorist who is credited with numerous works including: *Experiential Learning: Experience as the Source of Learning* (1984), *The Kolb Learning Style Inventory* (1999), and *The Process of Experiential Learning, and Facilitating Experiential Learning: Observations and reflections* (2006), developed a theoretical base for experiential learning. According to Kolb (1984), “Learning is the process whereby knowledge is created through the transformation of experience” (p. 38) Based on this belief, Kolb constructed the Experiential Learning Theory (ELT) (Figure 1), which states that the process of learning takes place in a four-stage cycle (Healey & Jenkins, 2000).



The concrete experience (CE) and abstract experience (AE) are stages in which the learner grasps or learns from their experiences. While the reflective observation (RO) and active experimentation (AE) are stages in which the learner transforms from the experience (Kolb, Boyatzis, & Mainemelis, 2001). The cycle can commence at any stage, however, it must be followed in sequence. The first stage, concrete experience, is where the learner actively experiences an activity. The second stage, reflective observation (RO), is where the learner reflects on their experience. The third stage, abstract conceptualization, the learner creates theories explaining their experience from reflections. The fourth stage, active experimentation, the learner plans how to use theory to solve problems or experimentation leading to new concrete experiences (Kolb, 1984). The learner should experience the cycle several times in order to produce a spiral effect (Healey & Jenkins, 2000).

Activities, such as laboratory or field exercises, are associated with the experiential learning theory. However, learning will not occur during these experiential activities, unless the learner is capable of making proper connections between each stage within the cycle (Healey & Jenkins, 2000; Jenkins, 1997). Kolb suggests that an individual's learning style determines how information is learned. According to Kolb (2000), there are four different types of learning styles.

1. *Divergers*. Learn better when placed in a situation that requires brainstorming;
2. *Assimilators*. Learn better when provided with information that permits them to deduce theoretical models;
3. *Convergers*. Learn better when given the opportunity to solve problems;

4. *Accommodators*. Learn better when given the opportunity to experience hands-on activities.

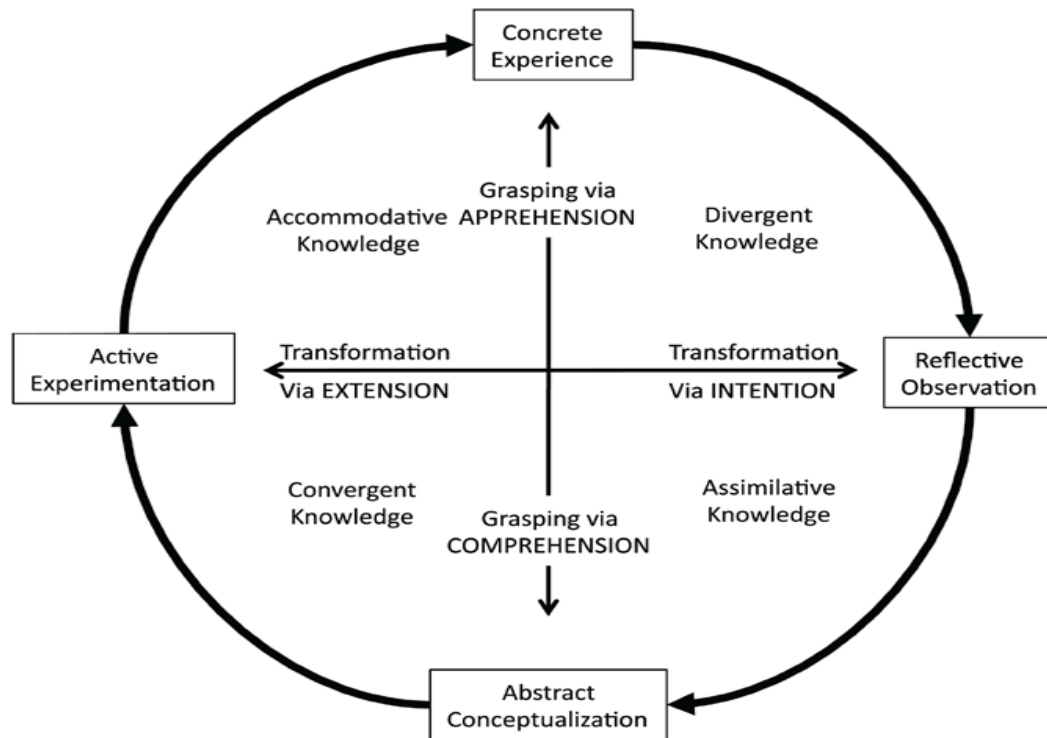


Figure 1. Kolb's model of experiential learning. Reprinted from "*Experiential Learning: Experience as the Source of Learning and Development*" by D. A. Kolb, 1984, Englewood Cliffs, NJ: Prentice-Hall, Inc. Copyright 1984 by Prentice-Hall, Inc. Reprinted with permission.

### Environmental Education in the Classroom

Water pollution, deforestation, waste management, species extinction, and increasing public health issues are only a few of the environmental concerns that have heightened the necessity for environmental education. With recent human caused environmental accidents, such the Tennessee River Valley Coal Ash Spill and the British Petroleum Oil Spill, only supports the need for environmental awareness through

environmental education. In 2008, the Tennessee River Valley Coal Ash Spill occurred as a result of a dike failure managed by Tennessee Valley Authority (TVA) and located the Kingston Fossil Plant in Roane County, Tennessee (EPA, 2016). There was approximately 5.4 million cubic yards of coal ash released in Emory River channel, which contained toxic concentrations of lead, barium, arsenic, boron, selenium, and other pollutants –all harmful to humans and wildlife. In 2010, the British Petroleum Oil Spill occurred as a result of an explosion and sinking of the Deepwater Horizon Oil rig in the Gulf of Mexico, forty-two miles away from Louisiana. There were approximately 3.19 million barrels of oil that leaked in the Gulf of Mexico, which had a devastating impact on marine life and Gulf Coast communities including massive deaths of the seabirds and fish, damage to various coral reefs, and obliteration of sea turtles nesting sites (Nikiforuk, 2016).

According to the *Environmental Education in the School: Creating a Program that Works*, a Peace Corps manual (Braus & Wood, 1993), environmental education is a process that promotes the empowerment of people through environmental awareness, which provides effective tools to solve environmental problems (Braus & Wood, 1993). In addition, environmental education can also aid in the increase in knowledge, skills, values, motivation, and personal commitment to maintaining environmental quality (Braus & Wood, 1993). Therefore, it is vital that K-12 educational institutions consider using environmental education as a tool to prepare student to address future environmental issues.

Environmental education can be taught in various forms, through integration throughout the curriculum, implemented segments of environmental education

sporadically through the curriculum, or integrated within the school as a full year or semester-long courses (Braus & Wood, 1993). Within these forms of teaching, teachers can utilize teaching strategies to teach environmental education. Teachers may use lectures and note taking as a teaching strategy, however, many teachers prefer experiential learning activities, which require students to experience learning. Laboratory experiments, outdoor investigations, cooperative learning, case studies, games and role-playing are examples of experiential learning activities, which encourage brainstorming, questioning, creativity, and critical thinking (Braus & Wood, 1993). Teaching environmental education requires that the educator directly relates environmental quality to the lives of the students. This permits the students to make a personal connection to the environment and understand how their actions affect their environment. As a result, the students have increased feelings of pride and self-respect because they have been empowered (Braus & Wood, 1993).

Environmental educational organizations, such as the North American Association of Environmental Education (NAAEE), advocate the advancement of K-12 environmental education programs at state and federal levels. In addition, NAAEE (2010) supports the development of environmental literacy plans; and offers supplement materials to aid in its implementation. Most importantly, it provides educators with the opportunity to share the best teaching practices for environmental education (NAAEE, 2010). Likewise, the government sponsored and supported environment education programs, such as Global Learning and Observations to Benefit the Environment (GLOBE), contribute greatly to the advancement of environmental education within K-12 since it offers teachers and students the opportunity to participate in international

environmental science investigations. To participate in the GLOBE program, the teachers must attend GLOBE workshops to receive training on observation protocols and learning activities. Then the teachers and their students would gain the ability to make observations focused on the atmosphere, climate, hydrology, landcover, soils, and phenology; and record their data onto GLOBE's online database. In addition, the data collected can be used to investigate trends and changes in their community and other communities around the world (GLOBE, 2016)

### Environmental Education Research

The Environment Protection Agency (EPA) (2016) defines environmental education as a process in which individuals are permitted the opportunity to explore environmental issues, participate in the problem-solving process, and take action to better environmental issues. The agency believes that the structure of environmental education is attributed to the following factors: 1) awareness and sensitivity; 2) knowledge and understanding; 3) attitudes; 4) skills; and 5) participation (EPA, 2016). Research both at the national and international level has shown that environmental education within the primary and secondary setting does have a positive effect on student knowledge and attitude. In addition, with research one can establish a relationship between environmental knowledge, environmental attitudes, and responsible behavior.

Many researchers support the development and implementation of environmental education within the school curriculum. El Salam, and coworkers (El Salam, El-Naggar, & Hussein 2009), found significant differences in Egyptian students' attitude and knowledge after doing coursework in environmental education. Students' negative attitude towards the environment was initially 80%, and after the course work, it was

22%. Student knowledge was obtained through the administration of a pre- and post-test. The pre-test revealed that 23% of the students were knowledgeable while after the posttest students' knowledge increased to a satisfactory level of 69%. So, El Salam and her colleagues (2009) concluded that environmental education positively affects students' attitude towards the environment and therefore should be implemented within the regular school curriculum.

In 2003, Bartosh, Ferguson, Tudor, and Taylor (2009) conducted a research study investigating the impact of environmental schools on student achievement when compared to traditional schools located in the state of Washington. An environmental school is one that actively abides by the Environmental Education Guidelines. The guidelines are 1) Help students develop knowledge about the environment and its effect on human interaction. 2) Help students develop an understanding of social and natural systems. 3) Help students understand how their personal decisions and actions can impact the environment. 4) Help students develop the skills and knowledge necessary to improve the environment. Bartosh et al. (2009) discovered that students attending the environmental education schools scored higher test scores on state standardized tests than those attending a traditional school. He also indicated that a cause-effect relationship existed between student achievement and the intensity of integration of environmental education in the school. So, it was concluded that environmental education does not only increase student academic achievement, but also improves students' behavior, motivation to learn, and perception of their importance in society (Bartosh et al., 2009).

In a study looking at environmental knowledge, environmental attitude, and environmentally responsible behavior using the Dutch National Assessment Program,

Kuhlemeier and colleagues (Kuhlemeier, van den Bergh, & Lagerweij, 1999) evaluated a sample of 9,000 secondary school students. The study showed a strong correlation between the studied criteria such as environmental attitude, willingness to make personal sacrifices, and environmentally responsible behavior. Kuhlemeier et al. (1999) concluded that students' perception of the environment affects how they act towards its sustainability

### Experiential Learning Research

According to the Association of Experiential Education (2016), experiential education is a method in which teachers engage students by direct experience and reflection. Experiential education programs such Full Option Science System (FOSS) and Projects WILD (Wildlife Investigations through Learning Designs) contribute greatly to student knowledge (Powell & Wells, 2002). These programs and others offer students informal educational opportunities that cultivate scientific reasoning abilities, comprehension of formal classroom information, self- efficacy, and interest in science-related careers (Weiberg, Basile & Albright, 2011).

In 2002, Oil City Elementary Magnet School in Oil City, Louisiana was targeted for closure due to declining test scores and enrollment numbers. However, the implementation of an environmentally focused learning increased test scores, enrollment, and parent and community involvement, which rescued the school from closure. The school's faculty received training from nationally recognized environmental education programs: Project Learning Tree, Project WILD, and Project WET. The faculty utilized lessons and materials that supported environmental education across the curriculum. The school's changes within the curriculum repositioned its reliance on textbooks to hands-on

activities. A school official said, “Our students are outdoors and moving while participating in learning activities practically every day” (Irvin, 2007). Within eight years of the implementation of environmentally focused curriculum, Oil City Magnet School increased its performance score from 40.4 to 89%. Student enrollment increased along with teacher retention; furthermore, teachers from around the district began requesting transfers to Oil City Magnet School. Most importantly, the teachers, parents and community exhibited a renewed commitment to setting a foundation established on critical thinking and authentic learning (Irvin, 2007).

### Experiential Environmental Education

Environmental education is widely known for its wide range of learning activities for practical hands-on experiences (Koutsoukos et al., 2015; Palmer & Neal, 2003), while experiential learning is recognized for its focus on knowledge acquisition through life experiences (Koutsoukos et al., 2015). A connection between environmental education and experiential learning results in the development of a learning system that “encourages participation in the learning experience and engages individuals in authentic, real-world experiences” (Koutsoukos et al., 2015).

Stepath (2006) conducted a study with the intention of investigating the changes in 11<sup>th</sup> and 12<sup>th</sup>-grade high school students’ environmental knowledge, attitude, and environmentally responsible behaviors when exposed to experiential education regarding coral reefs. The students received different educational interventions such as classroom presentation on coral reefs and reef monitoring of the Great Barrier Reef. Based on the students’ pre- and post-survey questionnaires and interviews, the coral reefs experience had a positive impact on the students’ environmental knowledge, attitude, and ecological



intention to act. Stepath (2006) suggests that educators should consider the implementation of natural environments into school curricular practice.

## CHAPTER III - METHODOLOGY

This chapter data describes the (1) research questions; (2) participants involved; (3) assessment instrument utilized; (4) research procedure employed that resulted in the collection of the data; and (5) statistical procedures used to analyze the data.

### Overview

The purpose of this study was to test the effectiveness of environmentally-based experiential learning activities, using the GLOBE program, on students' knowledge acquisition, critical thinking, students' attitude toward the environment, and career aspirations. The theoretical framework guiding this study was Kolb's Experiential Learning Model, which allows students to actively participate in their own learning and reflect upon their experience. This study utilized pre-tests/post-tests and pre-surveys/post-surveys to analyze the changes in knowledge acquisition, critical thinking, students' attitude toward the environment, and career aspirations. The pre-tests/post-tests were identified as the environmental knowledge assessment and critical thinking test. The pre-surveys/ post-surveys were identified as the students' attitude toward the environment survey and career aspirations survey. In addition, comparing the differences between the two groups assessed the effectiveness of environmentally-based experiential instruction: control and intervention. The control group only experienced traditional instruction; therefore received no environmentally-based experiential activities. The intervention group experienced the incorporation of environmentally-based experiential activities within instruction.

### Research Questions

This study addressed the following research questions:

1. What influence does environmental-based experiential learning activities have on knowledge acquisition among students, based on the Environmental Knowledge Assessment score?
2. What influence does environmental-based experiential learning activities have on students' critical thinking, based on the Cornell Critical Thinking Test Level X score?
3. What influence does environmental-based experiential learning activities have on students' attitude toward the environment, based on the Children's Environmental Attitude and Knowledge Scale score?
4. What influence does environmental-based experiential learning activities have on students' career aspirations, based on the Career Interest Survey (STEM-CIS) score?

#### Participants

The study consisted of a total of 50 middle school science students enrolled within a school district located in southwest Mississippi. The students were divided into two groups. The control group ( $n = 11$ ) was the students who did not experience the environmentally-based experiential learning activities within instruction. The intervention group ( $n = 39$ ) was the students who did experience the environmentally-based experiential learning activities within instruction. The participating teachers were responsible for administering the pre-tests/post-tests and pre-surveys/post-surveys to the students; however the teachers participating within the intervention group were required to incorporate environmentally-based experiential learning activities within instruction.

## Instrumentation

The following instruments were utilized for this study:

### *Environmental Knowledge Assessment*

The environmental knowledge assessment (Appendix D), comprising of 54 multiple-choice items from Triand Incorporated, was used to assess students' knowledge acquisition. Triand Incorporated is an online educational resource that provides state aligned test items. This assessment was constructed of Mississippi's state standard multiple-choice associated to environmental conditions such as air temperature, precipitation, and clouds provided by Triand Incorporated. The assessment items were selected based on the scientific information that would be shared during the GLOBE activities. GLOBE is an international environmental science and education program with the focus of collaboration among students, teachers, and scientists to gain a better understanding of the Earth and how to sustain and improve its environment at global and regional levels (Rojas, Zúñiga & Ugalde, 2015). Measurement protocols and learning activities, developed by GLOBE, offers instructors and students with teaching and learning opportunities, therefore GLOBE protocols were used as an environmental-based experiential learning tool.

### *Critical Thinking Test*

The Cornell Critical Thinking Test, developed by Robert Ennis and Jason Millman (1985), was used to assess critical thinking skills of the students. The Cornell Critical Thinking Test is a test that measures the critical thinking abilities of fifth through twelfth grade students. The test consisted of 71 multiple-choice questions that exam the students' critical thinking abilities. In addition, the test is divided into five sections that

measure induction, credibility, observations, deduction, and assumption identification.

Recent research has shown that Cornell Critical Thinking Test is a valid instrument that holds reliability values ranging between of .67-.90 (Bart, 2010). Permission to implement the survey was obtained from the authors through email.

#### *Attitude Towards the Environment Survey*

##### Children's Environmental Attitude and Knowledge Scale (CHEAKS)

(Appendix E), developed by Frank C. Leeming, William O'Dwyer, and Bruce A.

Bracken (1995) was used to assess students' attitude towards the environment. CHEAKS is an attitude survey used to assess a students' attitude towards the environment through the evaluation verbal commitment, actual commitment, and personal affect (Leeming, O'Dwyer, & Bracken, 1995). The CHEAKS survey consisted of 36 horizontal numeric scale questions with five possible responses to each statement 1= very true, 2 = mostly true, 3 = not sure, 4 = mostly false, and 5 = very false (Leeming et al., 1995). Recent research has shown that CHEAKS is a valid instrument that holds reliability values ranging between of .88-.90 (Leeming et al., 1995). Permission to implement the survey was obtained from the authors through email.

#### *Career Aspirations Survey*

The Career Interest Survey (STEM-CIS) (Appendix F), developed by Meredith W. Kier, Margaret Blanchard, Jason Osborne and Jennifer Albert (2014), is a survey created to measure interest in STEM education and careers. The survey was used to assess middle school students' interest in STEM education opportunities and careers (Kier et al., 2014). The survey consists of 44 Likert scale with five possible responses to each statement 1= strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 =

strongly agree. The questionnaire is divided into 4 sections that measure student interest in science, mathematics, engineering, and technology (Kier et al., 2014). Recent research has shown that STEM-CIS is a strong, single factor instrument that holds reliability values for science, technology, engineering, and mathematics of 0.77, 0.89, 0.85, and 0.86 (Kier et al., 2014). Permission to implement the survey was obtained from the authors through email.

### Research Procedure

Upon obtaining permission from the superintendent of the participating school district to conduct the study during fall of 2018, then I received IRB approval (Appendix A) from the University of Southern Mississippi. After receiving IRB approval, then I distributed the parental consent forms (Appendix B) to the participating teachers. The teachers dispersed the parental consent forms to every science student on their roster. The students returned the completed and signed parental consent forms to their teachers. Then, the teachers locked the completed and signed parental consent forms in a secure file cabinet. Soon after, the principal investigator collected and transferred the consent forms to an offsite locked secure file cabinet. The students who returned the completed and signed parental consent forms, then completed a child assent form (Appendix C) prior to participating in the study. The participating teachers locked the completed child assent forms in a secure file cabinet, soon after; the principal investigator collected and transferred the child assent forms to an offsite locked secure file cabinet. To maintain confidentiality, the principal investigator examined each completed and signed parental consent form and child assent form collected, then compiled a list of the names of the

participating students. Each participating student was assigned a de-personalized identifier ID number so responses would remain anonymous.

After the collection of the parental consent forms and child assent forms, the study consisted of 50 participating middle school science students, which consisted of three participated science teachers. The students were divided into two groups, control group ( $n=11$ ) and intervention group ( $n=39$ ). The participating students from each group were enrolled in a class of a participating middle school science teacher. One teacher participated within the control group, while two teachers participated within the intervention group. The teacher participating within the control group was only responsible for teaching current science concepts with traditional instruction and administering pre-tests/post-tests and pre-surveys/ post-surveys. The teachers participating within the intervention group were responsible for receiving GLOBE training, teaching current science standards with the incorporation environmentally-based experiential activities, administering pre-tests/post-tests and pre-surveys/post-surveys. Each teacher taught all classes the same instruction and administered the pre-tests/post-test and pre-survey/ post-surveys to each student; however this study only used the data from the students that returned completed parent consent forms and child assent forms.

This study required only the teachers participating in the intervention group to receive GLOBE training (Appendix H). The teachers were required to take part in a half-a-day GLOBE training session. The GLOBE training was initiated with an overview of the GLOBE program through the exploration of GLOBE's website ([www.globe.gov](http://www.globe.gov)). Afterwards, the session continued with an introduction to the GLOBE protocols that would be utilized throughout the study. The selected atmospheric GLOBE protocols

included: current temperature, surface temperature, precipitation, clouds, and relative humidity. The selected soil protocols included: soil pH and SMAP (Soil Moisture Measurement Protocol). These protocols were examined step-by-step which was accompanied with demonstrations of how to effectively execute the protocols using the required equipment. In addition, there was a review of state science standards and how to develop lessons plans incorporating the state science standards along with the environmentally-based experiential activities. Following the review of the protocols, the teachers were introduced to the research assessment instruments that included: Environmental Knowledge Assessment, Cornell Critical Thinking Test, Children's Environmental Attitude and Knowledge Scale (CHEAKS), and Career Interest Survey (STEM-CIS). The purpose and appropriate method of how to administer each assessment and survey was addressed. After a question and answer session, regarding GLOBE protocols and assessment instruments, then we transitioned to discussion of how to incorporate Kolb's Experiential Learning Model instruments (Appendix G) after performing GLOBE protocols. Lastly, the sites for equipment installation for the weather station and rain gauge were determined, preceding the discussion of in-person biweekly classroom visits accompanied with a GLOBE protocol checklist (Appendix I) for intervention implementation. Soon after, each participating teacher, within the intervention group, received a Teacher's GLOBE Notebook containing the GLOBE protocol materials, protocol equipment, and assessment instruments. The participating teacher, within the control group, only received the assessment instruments.

A week after training, the study proceeded as follows: 1) All teachers administered the pre-test of students' environmental knowledge using the Environmental



Knowledge Assessment with an estimated duration of 1 hour; 2) All teachers administered the pre-test of student's critical thinking using the Cornell Critical Thinking Test with a estimated time duration of 45 minutes; 3) All teachers administered the pre-survey of students' attitude towards the environment using the Children's Environmental Attitude and Knowledge Scale (CHEAKS) with an estimated duration of 30 minutes; 4) All teachers administered the pre-survey of the students' career aspirations using the Career Interest Survey (STEM-CIS) with an estimated duration of 30 minutes; 5) The researcher collected the bubble answer sheets for the pre-tests and pre-surveys and transferred them to an offsite locked secure file cabinet.; 6) The teachers within the control group taught current science concepts with traditional instruction, while the teachers within the intervention group taught current science concepts with the incorporation of environmentally-based experiential activities focused on atmospheric and soil conditions for the following five weeks, using the GLOBE protocols and the experiential learning model exercises. A description of the procedures taken by the teachers within the intervention group are listed within Chart 1; 7) The researcher observed the class sessions twice a week throughout the study using the GLOBE protocol checklist (Appendix I); 8) All teachers administered the post-test of students' environmental knowledge using the Environmental Knowledge Assessment with an estimated duration of 1 hour; 9) All teachers administered the post-test of student's critical thinking using the Cornell Critical Thinking Test with a estimated time duration of 45 minutes; 10) All teachers administered the post-survey of students' attitude towards the environment using the Children's Environmental Attitude and Knowledge Scale (CHEAKS) with an estimated duration of 30 minutes; 11) All teachers administered the

post-survey of the students' career aspirations using the Career Interest Survey (STEM-CIS) with an estimated duration of 30 minutes; 12) The researcher collected the bubble answer sheets for the post-tests and post-surveys and transferred them to an offsite locked secure file cabinet. Lastly, the researcher presented each participating teachers with a gift card as a token of appreciation, and offered them the opportunity to be trained on GLOBE protocols during the next academic year. Data from the study was generated from the pre-tests/post-tests and pre-surveys/post-surveys, which was entered into SPSS for descriptive statistics and mixed model analysis of variance (ANOVA) significance testing.

*Chart 1: Intervention Procedures*

<b>Week by Week Procedures for Intervention</b>	
<b><i>Week 1</i></b>	<ul style="list-style-type: none"> <li>• Installed the rain gauge and weather shelter.</li> <li>• Teachers administrated the Pre-tests/Pre-surveys to the students.</li> <li>• Pre-tests were Environmental Knowledge Assessment and Cornell Critical Thinking Test.</li> <li>• Pre-surveys were Children's Environmental Attitude and Knowledge Scale (CHEAKS) and Career Interest Survey (STEM-CIS).</li> </ul>
<b><i>Week 2</i></b>	<ul style="list-style-type: none"> <li>• Teachers and students performed the GLOBE Protocols: Current Temperature, Clouds, and Relative Humidity.</li> <li>• Teachers and students collected data based on observations from performing the GLOBE Protocols: Current Temperature, Clouds, and Relative Humidity.</li> <li>• Teachers and students recorded data on the GLOBE's Cloud, Temperature, and Relative Humidity data sheet (Appendix J).</li> <li>• Students completed the Kolb's Model of Experiential Learning Instruments (Appendix G) after performing the GLOBE protocols.</li> <li>• GLOBE Protocols were found in Teacher's GLOBE Notebook given to each teacher during the GLOBE training.</li> </ul>
<b><i>Week 3</i></b>	<ul style="list-style-type: none"> <li>• Teachers and students performed the GLOBE Protocols: Precipitation and Current Temperature.</li> <li>• Teachers and students collected data based on observations from performing the GLOBE Protocols: Precipitation and Current Temperature.</li> </ul>

	<ul style="list-style-type: none"> <li>Teachers and students recorded data on the GLOBE's Integrated 1-Day Data Sheet (Appendix K).</li> <li>Students completed the Kolb's Model of Experiential Learning Instruments (Appendix G) after performing the GLOBE protocols.</li> <li>GLOBE Protocols were found in Teacher's GLOBE Notebook given to each teacher during the GLOBE training.</li> </ul>
<b><i>Week 4</i></b>	<ul style="list-style-type: none"> <li>Teachers and students performed the GLOBE Protocols: Surface Temperature.</li> <li>Teachers and students collected data based on observations from performing the GLOBE Protocols: Surface Temperature.</li> <li>Teachers and students recorded data on the GLOBE's Surface Temperature Data Sheet (Appendix L).</li> <li>Students completed the Kolb's Model of Experiential Learning Instruments (Appendix G) after performing the GLOBE protocols.</li> <li>GLOBE Protocols were found in Teacher's GLOBE Notebook given to each teacher during the GLOBE training.</li> </ul>
<b><i>Week 5</i></b>	<ul style="list-style-type: none"> <li>Teachers and students performed the GLOBE Protocols: Soil pH.</li> <li>Teachers and students collected data based on observations from performing the GLOBE Protocols: Soil pH.</li> <li>Teachers and students recorded data on the GLOBE's Soil pH Data Sheet (Appendix M).</li> <li>Students completed the Kolb's Model of Experiential Learning Instruments (Appendix G) after performing the GLOBE protocols.</li> <li>GLOBE Protocols were found in Teacher's GLOBE Notebook given to each teacher during the GLOBE training.</li> </ul>
<b><i>Week 6</i></b>	<ul style="list-style-type: none"> <li>Teachers administrated the Post-tests/Post-surveys to the students.</li> <li>Post-tests were Environmental Knowledge Assessment and Cornell Critical Thinking Test.</li> <li>Post-surveys were Children's Environmental Attitude and Knowledge Scale (CHEAKS) and Career Interest Survey (STEM-CIS).</li> </ul>

### Treatment Fidelity

Hinckley and Douglas (2013) define treatment fidelity as the establishment of the reliability of the independent variable in a treatment study. According to Moncher and Prinz (1991) treatment fidelity stems from two concepts: treatment integrity and treatment differentiation. Treatment integrity is how well the treatment was implemented

as planned. Treatment differentiation refers to the existence of a manipulation among the independent variable due to substantial differences among the treatments (Moncher & Prinz, 1991). Treatment fidelity measurements are important because they permit the researcher gain an understanding of how the treatment attributes to the results of the study (Hinckley & Douglas, 2013). Therefore, this study employed the following steps to ensure treatment fidelity: 1) researcher provided GLOBE training to the teachers participating in the intervention group; 2) the researcher provided teachers participating in the intervention group support of how to develop lessons plans incorporating their current science objectives along with the environmentally-based experiential activities; 3) the researcher provided the necessary supervision related to implementation of environmentally- based experiential activities; and 4) researcher monitored intervention implementation by in-person biweekly classroom visits accompanied with a checklist.

#### Statistical Procedure

The mixed model analysis of variance (ANOVA) statistical procedure was used to analyze the data. For this study, the dependent variables were the assessments/survey scores used to measure the students' knowledge acquisition, critical thinking, and attitude towards the environment and career aspirations. The independent variable was the environmentally-based experiential intervention.

## CHAPTER IV- RESULTS

The purpose of this study was to determine the effectiveness of environmentally-based experiential learning activities, on students' knowledge acquisition, critical thinking, and attitudes toward the environment and career aspirations. The study relied heavily on the Global Learning and Observations to Benefit the Environment (GLOBE) program to accomplish set goals. This chapter presents the results data analysis from the Environmental Knowledge Assessment, Cornell Critical Thinking Test, Children's Environmental Attitude and Knowledge Scale Survey (CHEAKS), and Career Interest Survey (STEM-CIS). Quantitative data collected from these assessments and surveys were entered into SPSS for descriptive statistics and mixed model analysis of variance (ANOVA) significance testing.

### Research Questions

The scores from the various pre-test/pre-surveys and posttest/post surveys were used to test the research questions established for this study. The researcher manually graded all pre-tests/pre-surveys and post-tests/post-surveys. The researcher then entered the data in the SPSS software to conduct a mixed model analysis of variance (ANOVA). The results are as follows:

#### Research Question 1

*What influence does environmental-based experiential learning activities have on knowledge acquisition among students, based on the Environmental Knowledge Assessment score?*

The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Environmental Knowledge Assessment are shown in Table 1. For

the pre-test, the overall mean score for the control group and the intervention group was 17.66 with a standard deviation of 8.36. The data indicated that the pre-test mean for the control group was higher than the intervention group. For the post-test, students had an overall mean score of 20.54 and standard deviation of 9.17. The data indicated that the post-test mean for the control group remained higher than the intervention group. However, in the control group mean score decreased (24.45 to 21.18) while in the intervention the mean score increased (16.30 to 20.35), as seen in Figure 2. For the overall performance on the pretest and posttest, the results indicate that there was no significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = 1.45, p = .23$ . Indicating that for both groups together, the pre-test scores were not different from the post-test scores. However, there was a statistically significant interaction between type of instruction and its effect over time on the students' performance on the Environmental Knowledge Assessment pretest and posttest,  $F(1, 48) = 5.33, p = .025$ , which is depicted in Figure 3.

Table 1

*Descriptive Data of Environmental Knowledge Assessment*

	Group	Mean	Standard Deviation	N
Pretest	Control	22.45	8.28	11
	Intervention	16.30	7.97	39
	Total	17.66	8.36	50
Posttest	Control	21.18	10.88	11
	Intervention	20.35	8.78	39
	Total	20.54	9.17	50

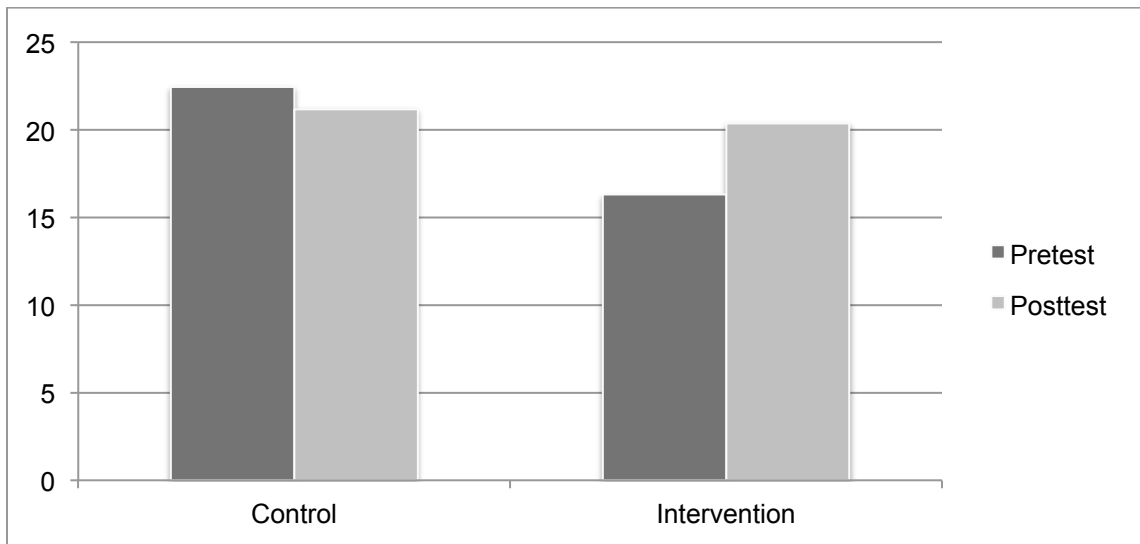


Figure 2. Pre-test and Post-test Environmental Knowledge Assessment means.

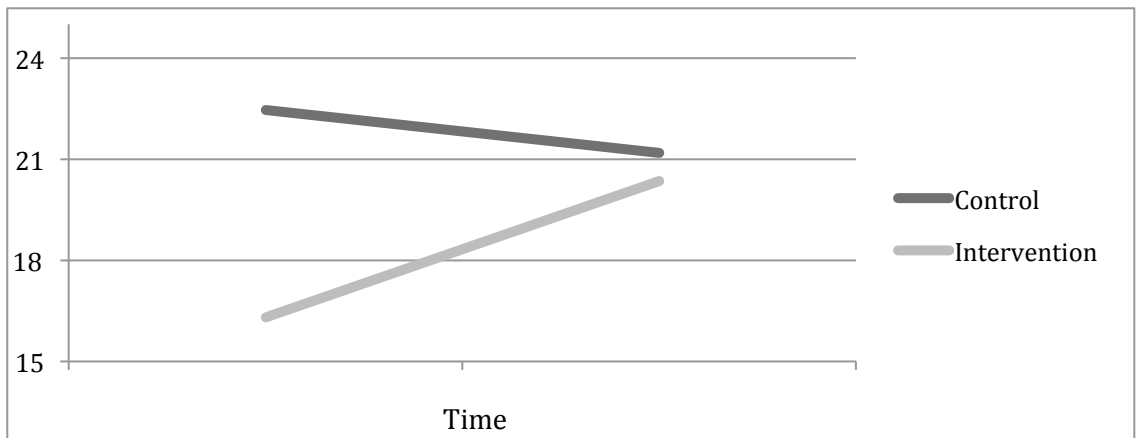


Figure 3. Estimated marginal means of Environmental Knowledge Assessment.

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

## Research Question 2

*What influence does environmental-based experiential learning activities have on students' critical thinking, based on the Cornell Critical Thinking Test score?*

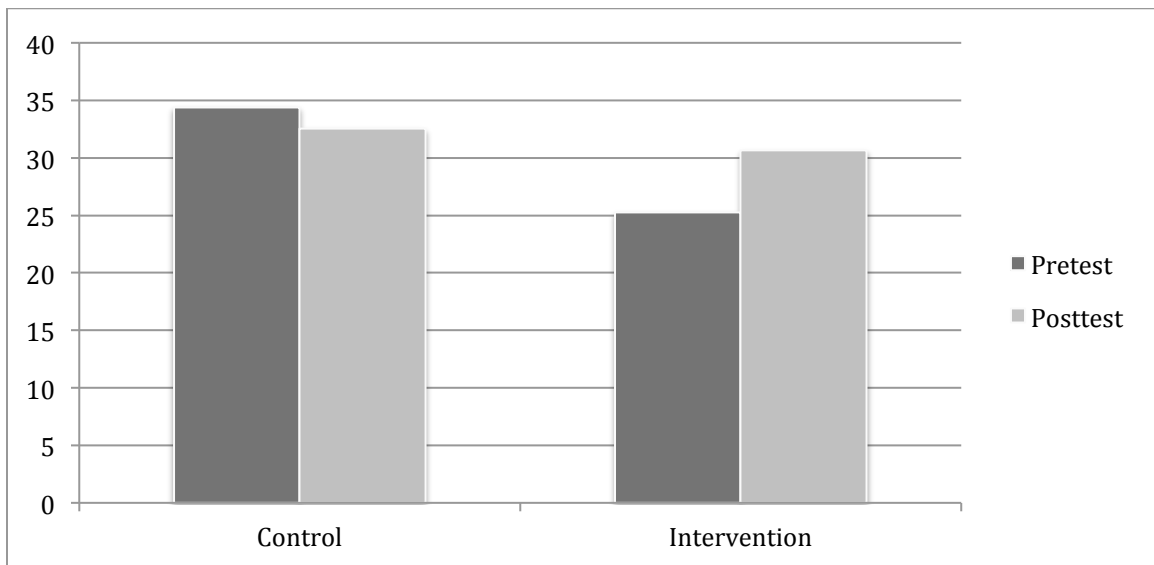
The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Cornell Critical Thinking Test are shown in Table 2. For the pre-test, students had an overall mean score of 27.26 and standard deviation of 12.62. The data indicated that the pre-test mean for the control group was higher than the intervention group. For the post-test, students had an overall mean score of 31.08 and standard deviation of 10.08. The data indicated that the post-test mean for the control group remained higher than the intervention group. However, the control group had a decrease in mean score (34.36 to 32.54); and the intervention group had an increase in mean score (25.25 to 30.66), as seen in Figure 4. The data indicated that the posttest mean for the control group remained higher than the intervention group. For the overall performance on the pre-test and post-test, the results indicated that there was no significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = 1.40, p = .24$ . Indicating that for both groups together, the pre-test scores were not different from the post-test scores. However, there was a statistically significant interaction between type of instruction and its effect over time on the students' performance on the Cornell Critical Thinking Test pre-test and post-test,  $F(1, 48) = 5.67, p = .021$ , which is depicted in Figure 5.



Table 2

*Descriptive Data of Cornell Critical Thinking Test*

	Group	Mean	Standard Deviation	N
Pretest	Control	34.36	8.57	11
	Experiment	25.25	12.93	39
	Total	27.26	12.62	50
Posttest	Control	32.54	9.66	11
	Experiment	30.66	10.28	39
	Total	31.08	10.08	50



*Figure 4. Pre-test and Post-test Cornell Critical Thinking Test means.*

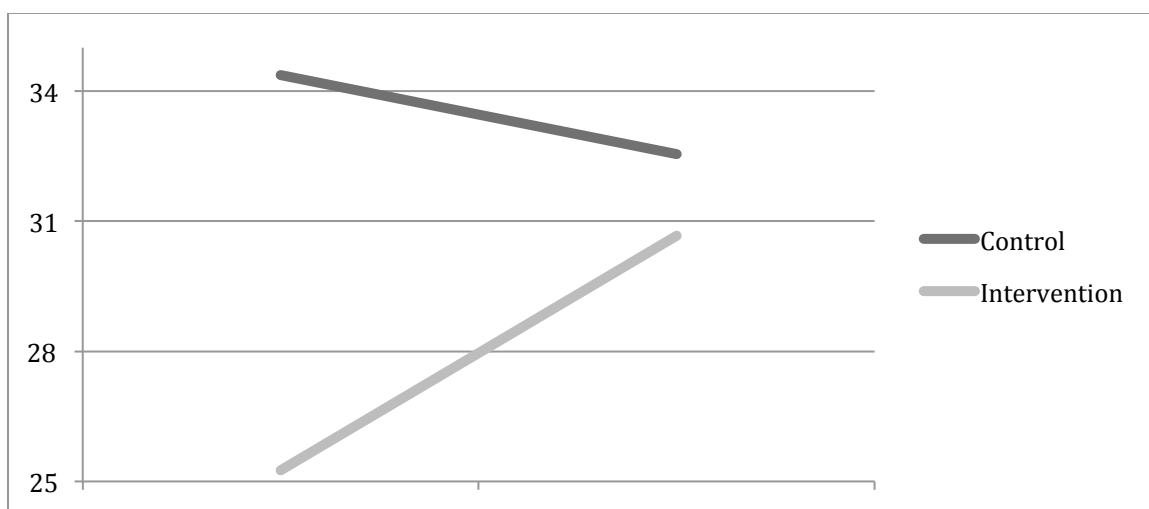


Figure 5. Estimated marginal means of Cornell Critical Thinking Test.

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

### Research Question 3

*What influence does environmental-based experiential learning activities have on students' attitude toward the environment, based on the Children's Environmental Attitude and Knowledge Scale score?*

The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Children's Environmental Attitude and Knowledge Scale (CHEAKS) are shown in Table 3. For the pretest, students had an overall mean score of 3.10 and standard deviation of 0.56. The data indicated that the pre-test mean for the control group was higher than the intervention group. For the post-test, students had an overall mean score of 3.38 and standard deviation of 0.49. The data indicated that the post-test mean for the intervention group was higher than the control group. The control group had an increase in mean score (3.32 to 3.36) for the pre-test and post-test and the intervention group had an increase in mean score (3.03 to 3.38), as seen in Figure 6. For

the overall performance on the pre-survey and post-survey, the results indicated that there was significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = 5.29, p = .026$ . Indicating that for both groups together, the pre-test scores were different from the post-test scores. However, there was no statistically significant interaction between type of instruction and its effect over time on the students' performance on the CHEAKS pre-survey and post-survey,  $F(1, 48) = 3.15, p = .082$ .

Table 3

*Descriptive Data of Children's Environmental Attitude and Knowledge Scale (CHEAKS)*

	Group	Mean	Standard Deviation	N
Pretest	Control	3.32	0.48	11
	Experiment	3.03	0.57	39
	Total	3.10	0.56	50
Posttest	Control	3.36	0.30	11
	Experiment	3.38	0.54	39
	Total	3.38	0.49	50

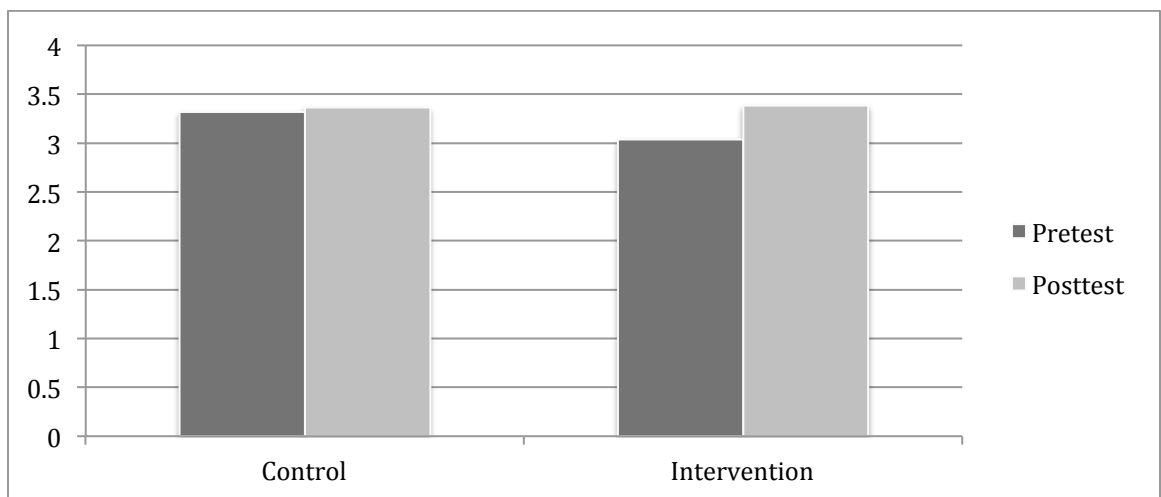


Figure 6. Pre-test and Post-test CHEAKS survey means.

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

#### Research Question 4

*What influence does environmental-based experiential learning activities have on students' career aspirations, based on the Career Interest Survey (STEM-CIS) score?*

#### Science

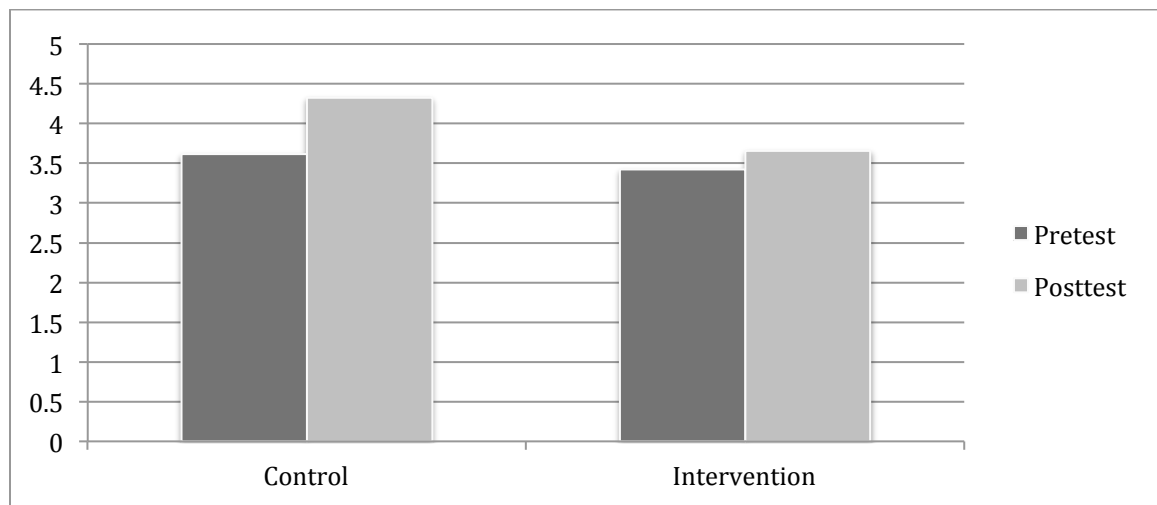
The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Career Interest Survey (STEM-CIS) for Science are shown in Table 4. For the pretest, students had an overall mean score of 3.46 and standard deviation of 1.15. The data indicated that the pre-survey mean for the traditional instruction group was higher than the intervention group. For the posttest, students had an overall mean score of 3.80 and standard deviation of 1.14. The data indicated that the post-survey mean for the control group was higher than the intervention group. The control group had an increase in mean score (3.61 to 4.32) for pretest and posttest; and the intervention group had an increase in mean score (3.42 to 3.65), as seen in Figure 7. For the overall performance on the pre-survey and post-survey, the results indicated that there was no significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = 3.08, p = .085$ . Indicating that for both groups together, the pre-test scores were not different from the post-test scores. In addition, there was no statistically significant interaction between the type of instruction and its effect over time

on the students' performance on the Career Interest Survey (STEM-CIS) for the science pre-survey and post-survey,  $F(1, 48) = 0.78, p = .38$ .

Table 4

*Descriptive Data of Career Interest Survey (STEM-CIS) for the Science*

	Group	Mean	Standard Deviation	N
Pretest	Control	3.61	0.34	11
	Experiment	3.42	1.29	39
	Total	3.46	1.15	50
Posttest	Control	4.32	1.39	11
	Experiment	3.65	1.03	39
	Total	3.80	1.14	50



*Figure 7. Pre-test and Post-test Career Interest Survey means (STEM-CIS) for Science.*

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

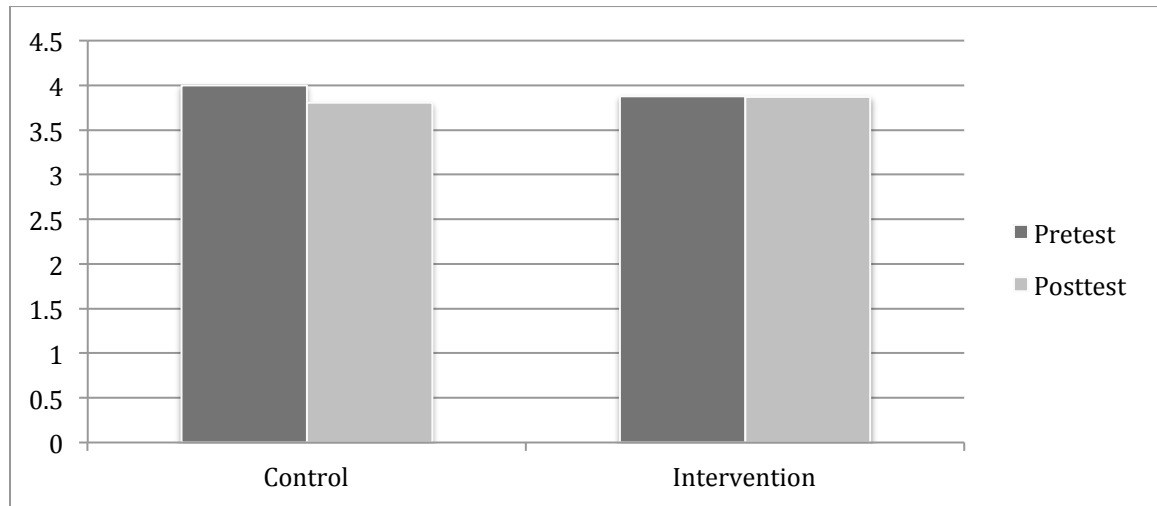
## *Technology*

The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Career Interest Survey (STEM-CIS) for Technology are shown in Table 5. For the pretest, students had an overall mean score of 3.84 and standard deviation of 0.89. The data indicated that the pre-survey mean for the control group was higher than the intervention group. For the posttest, students had an overall mean score of 3.87 and standard deviation of 0.97. The data indicated that the post survey mean for the control group was higher than the intervention group. The control group had an increase in the mean score (4.00 to 3.87) for pre-test and post-test; and the intervention group had an increase in mean score (3.80 to 3.86), as seen in Figure 8. For the overall performance on the pre-survey and post-survey, the results indicated that there was no significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = .019, p = .89$ . Indicating that for both groups together, the pre-test scores were not different for the post-test scores. In addition, there was no statistically significant interaction between the type of instruction and its effect over time on the students' performance in the Career Interest Survey (STEM-CIS) for the technology pre-survey and post-survey,  $F(1, 48) = .21, p = .64$ .

Table 5

*Descriptive Data of Career Interest Survey (STEM-CIS) for Technology*

	Group	Mean	Standard Deviation	N
<b>Pretest</b>	Control	4.00	0.68	11
	Experiment	3.80	0.95	39
	Total	3.84	0.89	50
<b>Posttest</b>	Control	3.87	0.86	11
	Experiment	3.86	1.00	39
	Total	3.87	0.97	50



*Figure 8. Pre-test and Post-test Career Interest Survey means (STEM-CIS) for Technology.*

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

*Engineering*

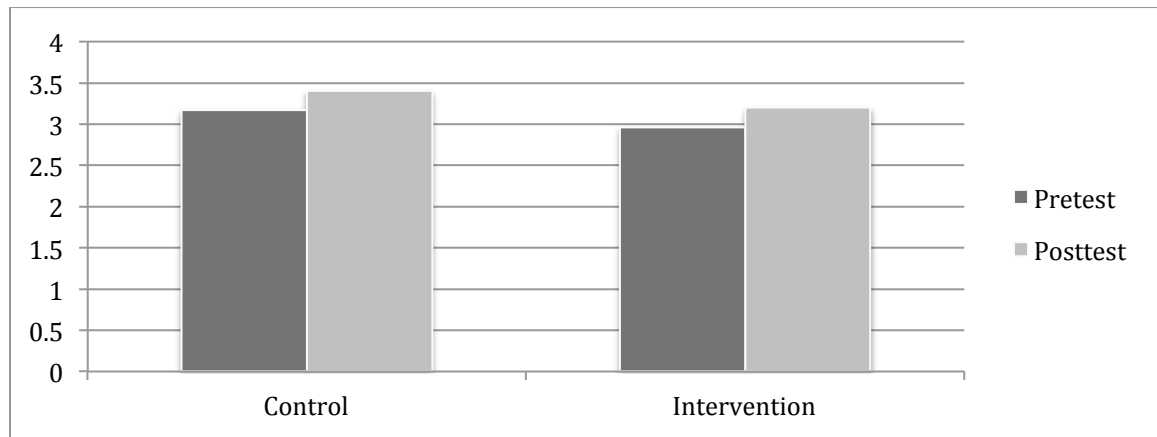
The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Career Interest Survey (STEM-CIS) for Engineering are shown in Table 6. For the pre-survey, students had an overall mean score of 3.17 and standard deviation of 0.87. The data indicated that the pre-survey mean for the control group was higher than the intervention group. For the post-survey, students had an overall mean score of 3.24 and standard deviation of 1.14. The data indicated that the post-survey means for the control group was higher than the intervention group. The traditional instruction group had an increase in mean score (3.17 to 3.40) for pre-survey and post-survey and the intervention group had an increase in mean score (2.95 to 3.20), as seen in Figure 9. For the overall performance on the pre-survey and post-survey, the results indicated that there was no significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = 1.29, p = .26$ . Indicating that for both groups together, the pre-test scores were not different for the post-test scores. In addition, there was no statistically significant interaction between the type of instruction and its effect over time on the students' performance on the Career Interest Survey (STEM-CIS) for the Engineering pre-survey and post-survey,  $F(1, 48) = .001, p = .98$ .



Table 6

*Descriptive Data of Career Interest Survey (STEM-CIS) for Engineering*

	Group	Mean	Standard Deviation	N
Pretest	Control	3.17	0.87	11
	Experiment	2.95	0.84	39
	Total	3.00	0.84	50
Posttest	Control	3.40	0.97	11
	Experiment	3.20	1.19	39
	Total	3.24	1.14	50



*Figure 9. Pre-test and Post-test Career Interest Survey means (STEM-CIS) for Engineering.*

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

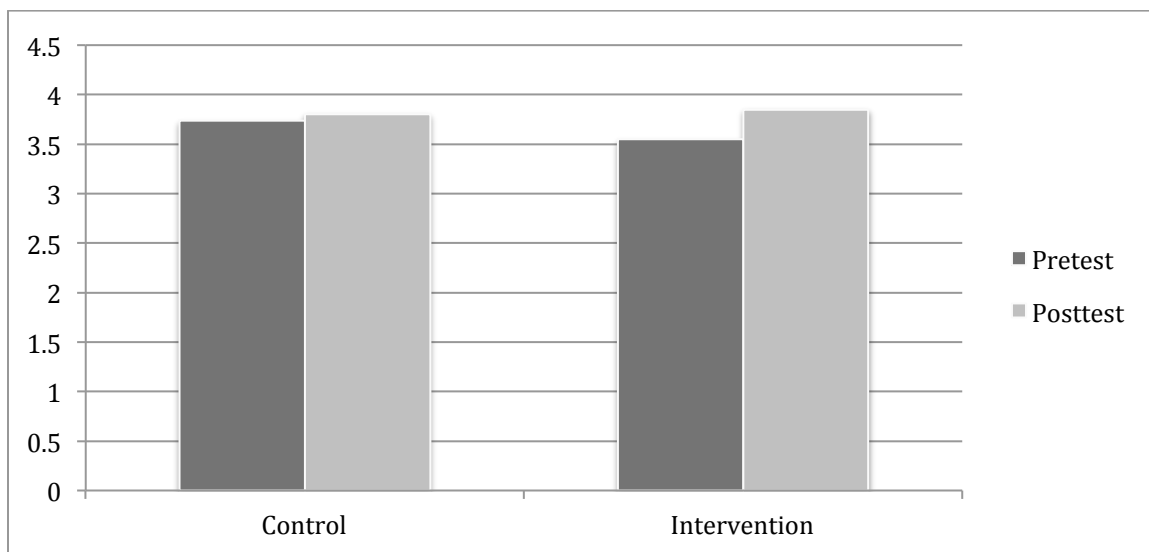
*Mathematics*

The descriptive data for students in the control and intervention groups on the pre-test and post-test of the Career Interest Survey (STEM-CIS) for Mathematics are shown

in Table 7. For the pre-survey, students had an overall mean score of 3.58 and standard deviation of 0.73. The data indicated that the pre-survey means for the control group was higher than the intervention group. For the posttest, students had an overall mean score of 3.84 and standard deviation of 1.07. The data indicated that the post survey means for the control group was higher than the intervention group. The control group had an increase in mean score (3.73 to 3.80) for pre-survey and post-survey and the intervention group had an increase in mean score (3.54 to 3.84), as seen in Figure 10. For the overall performance on the pre-survey and post-survey, the results indicated that there was no significant difference between the pre-test and post-test scores for both groups combined,  $F(1, 48) = .90, p = .34$ . Indicating that for both groups together, the pre-test scores were not different for the post-test scores. In addition, there was no statistically significant interaction between the type of instruction and its effect over time on the students' performance on the Career Interest Survey (STEM-CIS) for the Mathematics pre-survey and post-survey,  $F(1, 48) = .35 p = .55$ .

Table 7  
*Descriptive Data of Career Interest Survey (STEM-CIS) for Mathematics*

	Group	Mean	Standard Deviation	N
Pretest	Control	3.73	0.59	11
	Experiment	3.54	0.77	39
	Total	3.58	0.73	50
Posttest	Control	3.80	0.55	11
	Experiment	3.84	1.18	39
	Total	3.84	1.07	50



*Figure 10.* Pre-test and Post-test Career Interest Survey Means (STEM-CIS) for Mathematics

- \* Control: Traditional Instruction
- \* Intervention: Environmentally-Based Experiential Activities within Instruction

## CHAPTER IV- DISCUSSION

The purpose of this study was to determine the effectiveness of environmentally-based experiential learning activities, on students' knowledge acquisition, critical thinking, and attitudes toward the environment and career aspirations. The study relied heavily on the Global Learning and Observations to Benefit the Environment (GLOBE) program to accomplish set goals. Therefore, this study was designed to analyze the effectiveness of the incorporation of environmentally-based experiential learning activities using the GLOBE program and Kolb's Experiential Learning Model.

### Analysis of Research Questions

*Research Question 1:* What influence does environmentally-based experiential learning activities have on knowledge acquisition among students, based on the Environmental Knowledge Assessment score? Statistical analysis revealed that environmental-based experiential learning activities did not influence knowledge acquisition among students, based on the Environmental Knowledge Assessment scores. The results of ANOVA indicated there was a statistically significant interaction between types of instruction and its effect over time on the students' performance on the Environmental Knowledge Assessment pre-test and post-test. The findings indicated that the students that experienced the environmentally-based experiential learning activities, the intervention group, showed a gain in mean scores for knowledge acquisition with the Environmental Knowledge Assessment. Despite the gain for the intervention group, it maintained a mean score lower than the control group. The control group produced pre-test and post-test means higher than the intervention group but did show a decrease in mean scores. Based on the data, it is concluded that the incorporation of the

environmental-based experiential learning activities within instruction made a significant impact on students' knowledge acquisition. Therefore, the incorporation of the environmentally-based experiential learning activities within instruction had an effect over time on the student's knowledge synthesis (Lee and Caffarella, 1994).

*Research Question 2.* What influence does environmentally-based experiential learning activities have on students' critical thinking, based on the Cornell Critical Thinking Test Level X score? Statistical analysis revealed that environmentally-based experiential learning activities do have an influence on critical thinking among students, based on the Cornell Critical Thinking Test scores. The results of ANOVA indicated there was a statistically significant interaction between types of instruction and its effect over time on the students' performance on the Cornell Critical Thinking Test score pre-test and post-test. The findings indicated that the students who experienced the environmental-based experiential learning, the intervention group, showed a gain in mean scores for critical thinking with the Cornell Critical Thinking Test. Despite the gain for the intervention group, it maintained a means scores lower than the control group. The control group produced pre-test and post-test means higher than the intervention group but did show a decrease in mean scores. Based on the data, it is concluded that the incorporation of the environmental-based experiential learning activities within instruction does make a significant impact on students' critical thinking. According to Gunn, Grigg, and Pomahac, (2008), processes such as experience, observation, reasoning, and reflection are essential to critical thinking. The environmental-based experiential learning activities gave the students within the intervention group the opportunity experience, observe and reflect upon their experiences.

*Research Question 3.* What influence does environmentally-based experiential learning activities have on students' attitude toward the environment, based on the Children's Environmental Attitude and Knowledge Scale (CHEAKS) score? Statistical analysis revealed that environmentally-based experiential learning activities did not influence students' attitude toward the environment, based on the CHEAKS scores. The results of ANOVA indicated there was a statistically significant difference in the overall students' performance on the pre-survey and post-survey. Additionally, the results of ANOVA indicated there was no statistically significant interaction between types of instruction and its effect over time on the students' performance on the CHEAKS pre-survey and post-survey. The findings indicated that the students within both groups showed a gain in mean scores for students' attitude toward the environment for the CHEAKS survey. Since the CHEAKS survey measured students' responses by a set of numeric scale questions with five possible responses to each statement (1= very true, 2 = mostly true, 3 = not sure, 4 = mostly false, and 5 = very false), it was concluded that both groups of students maintained a similar attitude toward the environment as the overall mean scores for pre-survey and post-survey ranged from 3.10 to 3.38. Based on the data, it is concluded that the incorporation of the environmental-based experiential learning activities within instruction made a significant impact on students' attitude toward the environment. Therefore, the incorporation of the experiential learning activities within instruction did affect student's attitude toward the environment.

*Research question 4.* What influence does environmentally-based experiential learning activities have on students' career aspirations, based on the Career Interest Survey (STEM-CIS) score?

### *Science*

Statistical analysis revealed that environmentally-based experiential learning activities did not influence students' career aspirations, based on the Career Interest Survey (STEM-CIS) for the Science scores. The results of ANOVA indicated there was no statistically significant interaction between type of instruction and its effect over time on the students' performance on the Career Interest Survey (STEM-CIS) for the Science pre-survey and post-survey. The findings indicated that the students within both groups showed a gain in mean scores for students' career aspirations towards a career in science for the Career Interest Survey (STEM-CIS) survey. Since the survey consisted of a Likert scale with five possible responses to each statement 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree, it can only be concluded that both groups of students had increasing interest in science (overall mean scores: 3.46 to 3.80). However, the control group experienced a higher gain in mean scores than the intervention group. Based on the data, it is concluded that the incorporation of the environmental-based experiential learning activities within instruction did not make a significant impact on students' career aspiration towards science. Therefore, the incorporation of the environmentally-based experiential learning activities within instruction did not affect the students' science career aspirations.

### *Technology*

Statistical analysis revealed that environmentally-based experiential learning activities did not influence students' career aspirations, based on the Career Interest Survey (STEM-CIS) for the Technology scores. The results of ANOVA indicated there was no statistically significant interaction between type of instruction and its effect over

time on the students' performance on the Career Interest Survey (STEM-CIS) for the Technology pre-survey and post-survey. The findings indicated that the intervention groups showed a gain in mean scores for students' career aspirations towards a career in technology for the Career Interest Survey (STEM-CIS) survey. Since the survey consisted of a Likert scale with five possible responses to each statement (1= strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree), it can only be concluded that the intervention group had a very slight increase in interest in technology (overall means scores: 3.80 to 3.86). Based on the data, it is concluded that the incorporation of the environmental-based experiential learning activities within instruction did not make a significant impact on students' career aspiration towards technology. Therefore, the incorporation of the environmentally-based experiential learning activities within instruction did not affect the students' technology career aspirations.

### *Engineering*

Statistical analysis revealed that environmentally-based experiential learning activities did not influence students' career aspirations, based on the Career Interest Survey (STEM-CIS) for the Engineering scores. The results of ANOVA indicated there was no statistically significant interaction between type of instruction and its effect over time on the students' performance on the Career Interest Survey (STEM-CIS) for the Engineering pre-survey and post-survey. These findings indicated that the students within both groups showed a gain in mean scores for their aspirations towards a career in engineering for the Career Interest Survey (STEM-CIS) survey. Since the survey consisted of a Likert scale with five possible responses to each statement (1= strongly



disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree), it can only be concluded that both groups were undecided with engineering going by the overall pre-survey, and post-survey mean scores (3.00 to 3.24). Based on the data, it is concluded that the incorporation of the environmental-based experiential learning activities within instruction did not make a significant impact on students' career aspiration towards engineering. Therefore, the incorporation of the environmentally-based experiential learning activities within instruction did not affect the students' engineering career aspirations.

### *Mathematics*

Statistical analysis revealed that environmentally-based experiential learning activities did not influence students' career aspirations, based on the Career Interest Survey (STEM-CIS) for the Mathematics scores. The results of ANOVA indicated there was no statistically significant interaction between type of instruction and its effect over time on the students' performance on the Career Interest Survey (STEM-CIS) for the Mathematics pre-survey and post-survey. These findings indicated that the students within both groups showed a gain in mean scores for students' career aspirations towards a career in mathematics for the Career Interest Survey (STEM-CIS) survey. Since the survey consisted of a Likert scale with five possible responses to each statement (1= strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree), it was concluded that the intervention group had a very slight increase in interest in mathematics (overall means scores: 3.58 to 3.84). Based on the data, it is concluded that the incorporation of the environmental-based experiential learning activities within instruction did not make a significant impact on students' career aspiration towards

mathematics. Therefore, the incorporation of the environmentally-based experiential learning activities within instruction did not affect the students' mathematics career aspirations.

In addition, the Kolb's Experiential Learning Model instruments were utilized throughout the study following the completion of each GLOBE protocol, and the students' responses contributed greatly to the process of implementing the environmental-based learning activities within this study. However, the students' responses were not deeply examined for the purposes of this study.

### Conclusion

The purpose of this study was to determine the effectiveness of environmentally-based experiential learning activities on students' knowledge acquisition, critical thinking, and attitudes toward the environment and career aspirations. This was a quantitative study based on the scores of the Environmental Knowledge Assessment, Cornell Critical Thinking Test, Children's Environmental Attitude and Knowledge Scale (CHEAKS) Survey, and Career Aspirations Survey. Each assessment and survey was administrated as a pretest/posttest to determine differences in gain scores for the control and intervention groups. A mixed ANOVA design was used to compare the differences in gain scores of the students who experienced the environmentally-based experiential learning activities during instruction and those who experienced only traditional instruction.

The mixed ANOVA results indicated that the incorporation of environmentally-based experiential learning activities supported by GLOBE activities and Kolb's Experiential Learning Model instruments proved to play a significant role in increasing

student knowledge acquisition and critical thinking skills. However, these activities did not prove to be effective in improving students' attitude toward the environment especially as it relates environmental sustainability. Also, it was not effective in improving students' drive towards a career in STEM.

#### Limitations

This study had some limitations that have to be addressed. First, the study was limited to six weeks, due to the school districts' uncertainty of how this study would affect teachers' ability to prepare the eighth grade science students for their Mississippi Academic Assessment Program (MAAP) Science Test. The concern of the timeframe for the study was understandable however, an extended timeframe would have permitted the teachers and students more time to familiarize themselves with the GLOBE protocol and Kolb's Learning Model instruments that could have contributed to an increase of transparency, which may have positively impacted the students' overall performance. Second, the GLOBE training was initially planned to occur for a two day time period, however the GLOBE training was limited to half of the day. It was limited to half of the day due the administrators concern of loss of instruction for the participating teachers. An extended amount of training of the GLOBE protocols would have enhanced the participating teachers' knowledge and understanding of the purpose of each protocol, which could have positively affected the students' experience. Third, this study was limited to students within the middle school educational stage that excluded students within the elementary and high school educational stages. It would be helpful to understand how environmental-based experiential learning activities would affect students of various educational stages. Fourth, this study did not consider the teachers'

attitude towards science, their educational background, or teaching experience. It would be useful to understand how these factors could have impacted the results of this study. Fifth, the Mississippi Academic Assessment Program (MAAP) Science Test, a required state test for public schools in Mississippi, played a major impact on the low willingness of various public school districts to participate in this study. Many administrators were simply concerned about how this study may negatively impact the teachers' ability to instruct, which would negatively affect students' Mississippi Academic Assessment Program (MAAP) Science Test scores. The limitation of only including public schools resulted in lack of participation. Therefore, it would have been helpful to extend the study to the private school sector, since these schools do not have to adhere to the state curriculum and state testing.

#### Recommendations for Future Research

1. Extend the duration of this study to a minimum of nine weeks.
2. Extend participation to include other educational stages, such as elementary and high school.
3. Consider the teachers' attitude towards science, their educational background, and teaching experience, as major factors within the study.
4. Extend participation to various schools within the private school sectors.

## APPENDIX A – IRB Approval Letter



### INSTITUTIONAL REVIEW BOARD

118 College Drive #5147 | Hattiesburg, MS 39406-0001

Phone: 601.266.5997 | Fax: 601.266.4377 | [www.usm.edu/research/institutional.review.board](http://www.usm.edu/research/institutional.review.board)

### NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.  
Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 17061202

PROJECT TITLE: The Utilization of Environmental-Based Experiential Learning activities and its Influence on Students' Knowledge Acquisition, Critical Thinking, Attitude Towards the Environment, and Career Aspirations

PROJECT TYPE: New Project

RESEARCHER(S): Veshell Lewis

COLLEGE/DIVISION: College of Science and Technology

DEPARTMENT: Center for Math and Science Education

FUNDING AGENCY/SPONSOR: N/A

IRB COMMITTEE ACTION: Exempt Review Approval

PERIOD OF APPROVAL: 11/16/2017 to 11/15/2018

**Lawrence A. Hosman, Ph.D.**

**Institutional Review Board**

APPENDIX B – Parent Consent Form

**AUTHORIZATION TO PARTICIPATE IN  
RESEARCH PROJECT**

**Consent is hereby given to participate in the study titled:**

The Utilization of Environmental-Based Experiential Learning Activities and Its Influence on Students' Knowledge Acquisition, Critical Thinking, Attitude Towards the Environment, and Career Aspirations

1. **Purpose:** The purpose of this study is to investigate the effectiveness of environmental-based experiential learning activities on students' knowledge acquisition, critical thinking, attitude towards the environment, skill mastery and career aspirations. The study will rely heavily on the Global Learning and Observations to Benefit the Environment (GLOBE) program to accomplish set goals.
2. **Description of Study:** This study is designed to test the effectiveness of environmentally-based experiential learning activities, using the GLOBE program, on students' knowledge acquisition, critical thinking, students' attitude toward the environment, and career aspirations. The theoretical framework guiding this study is Kolb's Experiential Learning Model, which allows students to actively participate in their own learning. The study will require the participation of approximately 200-245 middle school students enrolled in a middle school within South Pike School District, located in southwest Mississippi. The students will experience environmental-based experiential learning activities. This study will utilize pre-tests/post-tests and pre-surveys/post-surveys to analyze the changes in knowledge acquisition, critical thinking, students' attitude toward the environment, and career aspirations. The Environmental Knowledge Assessment, comprising of 54 multiple-choice items from Triand Incorporated, will be used to assess students' knowledge acquisition. The Cornell Critical Thinking Test Level X, developed by Robert Ennis and Jason Millman (1985), will be used to assess critical thinking skills of the students. Children's Environmental Attitude and Knowledge Scale (CHEAKS), developed by Frank C. Leeming, William O'Dwyer, and Bruce A. Bracken (1995), will be used to assess students' attitude towards the environment. The Career Interest Survey (STEM-CIS), developed by Meredith W. Kier, Margaret Blanchard, Jason Osborne and Jennifer Albert (2013), is a survey created to measure interest in STEM education and careers. In addition, the participants will maintain a journal regarding observations made during activities.
3. **Benefits:** Based on research, the implementation of environmental-based experiential education within Mississippi educational institutions may contribute to the increase of scientifically literate

students prepared to compete for degrees and careers in STEM. Therefore, this study will provide an opportunity for students, parents, teachers, and school administrators to gain an understanding of the effectiveness of environmental-based experiential learning activities.

- 4. **Risks:** There will be no use of methods that will employ potential risks, inconveniences or discomforts.
  
- 5. **Confidentiality:** The participants’ responses to the pre-tests/post-tests and pre-surveys/post-surveys will be anonymous. The data collected will be coded using numbers or pseudonyms, therefore the names and identifiers such as student ID will not be used. The data will be stored in a locked file cabinet or password-protected computer file.
  
- 6. **Alternative Procedures:** There are no alternative procedures.
  
- 7. **Participant's Assurance:** Whereas no assurance can be made concerning results that may be obtained (since results from investigational studies cannot be predicted) the researcher will take every precaution consistent with the best scientific practice. Participation in this project is completely voluntary, and participants may withdraw from this study at any time without penalty, prejudice, or loss of benefits. Questions concerning the research should be directed to Veshell Lewis at 601-270-2806. This project and this consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5116, Hattiesburg, MS 39406-0001, (601) 266-5997. A copy of this form will be given to the participant.
  
- 8. **Signatures:** In conformance with the federal guidelines, the signature of the participant or parent or guardian must appear on all written consent documents.

_____ Signature of the Research Participant	_____ Date
_____ Signature of the Person Explaining the Study	_____ Date

In instances where the participant is a minor (under the age of eighteen years), a signature line for the minor's assent and a signature line for the parents/guardians' consent is required:

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Signature of the Minor Research Participant

---

Date

---

Signature of Parent/Guardian

---

Date

Participant's Initials \_\_\_\_\_



## APPENDIX C – Child Assent Form

### Child Assent Form

I am doing a study to gain the purpose of this study is to test the effectiveness of environmentally-based experiential learning activities, on students' knowledge acquisition, critical thinking, attitude toward the environment, skill mastery and career aspirations. The study will rely heavily on the Global Learning and Observations to Benefit the Environment (GLOBE) program to accomplish set goals.

If you agree to be in our study, I am going to ask you to complete a pre- and post-tests, attitude assessment instrument, performance tasks, career interest questionnaire, and journal writing. You can ask questions about this study at any time. If you decide at any time not to finish, you can ask us to stop. The assessment and survey we will only assess your knowledge and interest. The assessment and survey will not affect the academic grade in any way.

If you sign this paper, it means that you have read this and that you want to be in the study. If you don't want to be in the study, don't sign this paper. Being in the study is up to you, and no one will be upset if you don't sign this paper or if you change your mind later.

Your signature: \_\_\_\_\_ Date \_\_\_\_\_

Your printed name: \_\_\_\_\_ Date \_\_\_\_\_

Signature of person obtaining consent: \_\_\_\_\_

Date \_\_\_\_\_

Printed name of person obtaining consent: \_\_\_\_\_

Date \_\_\_\_\_



## **Knowledge Assessment**

Student name:

Author: Veshell Lewis

- 
- 1 The equation below can be used to convert Celsius temperature,  $C$ , to Fahrenheit temperature,  $F$ .

$$F = 1.8C + 32$$

What is the Fahrenheit temperature when the Celsius temperature is 20 degrees?

- A 33.8 degrees Fahrenheit
- B 50 degrees Fahrenheit
- C 53.8 degrees Fahrenheit
- D 68 degrees Fahrenheit



- 2 The formula used for converting the temperature from Fahrenheit (F ) to Celsius ( C ) is  $^{\circ}\text{C} = \frac{5}{9}(^{\circ}\text{F} - 32)$ . The outside temperature is  $80^{\circ}\text{F}$ .

About what is this temperature in degrees Celsius?

- A  $27^{\circ}\text{C}$
- B  $45^{\circ}\text{C}$
- C  $80^{\circ}\text{C}$
- D  $140^{\circ}\text{C}$

- 3 Corey recorded the outside temperature every 3 hours starting at 7 a.m. one day.

**Outside Temperatures**

Time of Day	Temperature ( $^{\circ}\text{F}$ )
7 A.M.	60
10 A.M.	65
1 P.M.	67
4 P.M.	65
7 P.M.	62

Which statement describes how the temperature changed as time passed during the day?

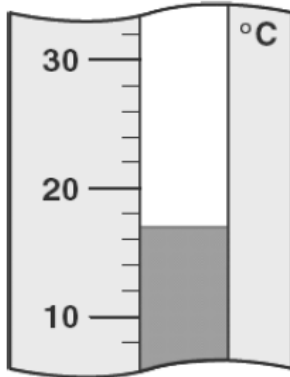
- A The temperature decreased as time passed.
- B The temperature decreased then increased as time passed.
- C The temperature increased as time passed.
- D The temperature increased then decreased as time passed.

- 4 Which of the following **best** describes the climate of an area?

- A the high temperature and wind speed for six months
- B the high temperature and wind speed each day for one year
- C the temperature and precipitation every hour for one day
- D the average temperature and total precipitation each month for ten years



- 5 The thermometer below shows the temperature at an indoor skating rink.



What temperature is shown on this thermometer?

- A** 14°C
- B** 23°C
- C** 17°C
- D** 22°C



- 
- 6 Stella researched monthly weather conditions for her town over seven months. The following chart shows the data she found.

**Weather Conditions**

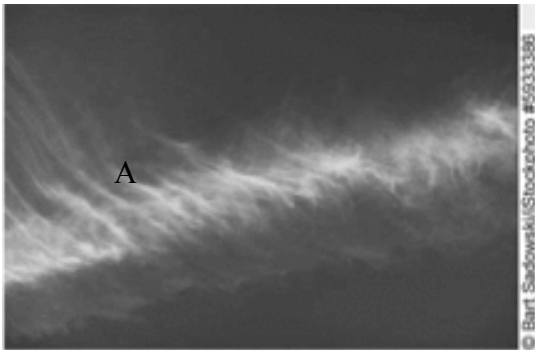
Month	January	February	March	April	May	June	July
Average Temperature (degrees Fahrenheit)	54	58	62	70	78	88	94
Precipitation (inches)	0.7	0.8	0.9	0.3	0.1	0.1	0.8

Which statement describes the weather changes from January through July for Stella's town?

- A The precipitation decreased, but the temperature increased.
- B The temperature and precipitation both increased every month.
- C The precipitation stayed the same, and the temperature doubled.
- D The temperature increased, but precipitation both increased and decreased.



- 7 A student looked outside the window and saw rain. The rain was slow and gentle. What type of clouds did the student see?



Cirrus



Cumulus







Nimbostratus



Cumulonimbus



- 8 Different types of clouds are used to predict weather.

Types of Clouds			
	Picture	Description	Weather
Cirrus		Thin and wispy, high in the sky	No rain, fair weather
Cumulus		Large and puffy, have a flat bottom, low in sky	No rain
Cumulonimbus		Tall and wide, dark bottoms, low in the sky	Heavy rain, thunder and lightning
Stratus		Dark and gray, cover entire sky, low in the sky	Light to medium rain

What type of cloud is most likely seen in the sky during a thunderstorm?

- A** Cirrus
- B** Cumulus
- C** Cumulonimbus
- D** Stratus
- 9 A student wants to know what types of clouds are in the sky during different types of weather. Which investigation should the student complete to answer this question?
- A** observe the clouds in the sky during rainy, sunny, and snowy weather
- B** observe the clouds in the sky during three days of sunny weather
- C** observe the clouds in the sky during a rainstorm
- D** observe the clouds in the sky during two days of snowy weather





- 
- 10 The weather forecast says a heavy snowstorm is coming later today.  
Which weather observation is likely just before the snow?

A clear sky  
B thick grey clouds  
C small white clouds  
D warm temperature

- 11 A student looked out the window and saw nimbostratus clouds.

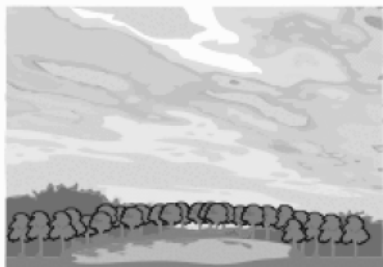


These clouds will **most** likely produce what type of weather?

A rainy  
B sunny  
C fair  
D hail



- 12 The clouds shown in the picture below look like gray sheets that spread across the sky. They form at 1500 meters and may bring heavy mist, snow, or drizzle.



What type of clouds are these?

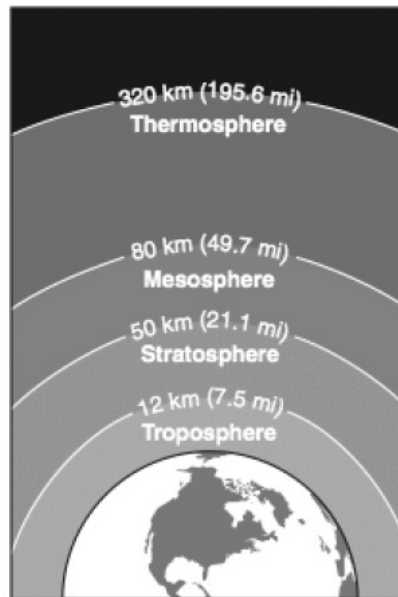
- A Cirrus
- B Cumulus
- C Cumulonimbus
- D Stratus



**13** Clouds are formed when millions of drops of water become suspended in the air. Which of the following is a step in the process of cloud formation?

- A** Expansion of cold air
- B** Formation of carbon dioxide
- C** Condensation of water vapor
- D** Breakdown of atmospheric ozone

**14** The diagram below shows layers of Earth's atmosphere.



Which layer of the atmosphere has clouds and weather?

- A** troposphere
- B** stratosphere
- C** mesosphere
- D** thermosphere



15 Which process forms clouds?

- A runoff
- B snowing
- C condensation
- D precipitation

16 Which structure is contained in the hydrosphere?

- A Clouds
- B Lakes
- C Rocks
- D Trees

17 Sulfur dioxide and nitrogen oxides are gases from factories, power plants, and automobiles that enter the air as pollution.

Which of the following statements must occur for acid rain to form from air pollution?

- A Winds have to carry the acids over oceans.
- B The gases have to combine with water vapor.
- C The gases have to form cumulonimbus clouds.
- D Winds have to mix the gases in specific proportions.

18 Students observe rain falling outside. Three hours later, the students observe snow falling. What **most likely** caused the rain to change to snow?

- A The air temperature became cooler.
- B The clouds became darker.
- C The wind became stronger.
- D The sunlight became stronger.

19 Which of these shows the processes water goes through, in order, as it moves from the surface of the ocean to when it becomes part of the cloud?

- A evaporation, then precipitation
- B precipitation, then evaporation
- C evaporation, then condensation
- D condensation, then evaporation

20 Which two processes in the water cycle are primarily responsible for the creation of a lake?

- A evaporation and runoff
- B evaporation and condensation
- C precipitation and runoff
- D precipitation and condensation

21 Which of the following allows water to move from Earth's surface back into the air?

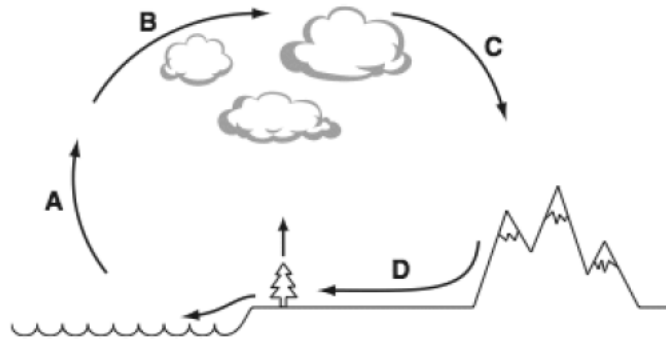
- A gravity
- B weathering
- C condensation
- D evaporation



22 Glaciers cover about 10% of the total land area on Earth. The role of glaciers in the water cycle is to

- A filter salt water
- B store fresh water
- C move liquid water
- D precipitate solid water

23 Look at the diagram below.



In which location on the diagram is water changing from a liquid to a gas?

- A A
- B B
- C C
- D D

24 Water evaporating from the surface of a lake moves from the

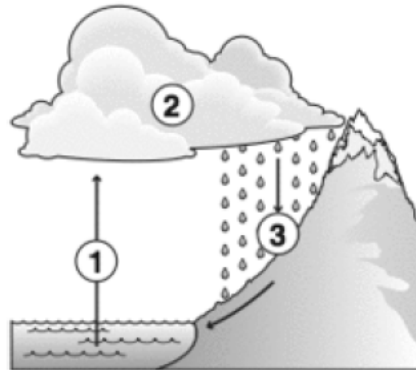
- A atmosphere to the geosphere.
- B geosphere to the hydrosphere.
- C hydrosphere to the atmosphere.
- D atmosphere to the hydrosphere.

25 In the water cycle, rain, snow, or sleet falling to the ground is a form of

- A precipitation.
- B condensation.
- C evaporation.
- D transpiration.



26 Use the drawing of the water cycle below to answer this question.



Which terms match the number order of the processes shown in the water cycle?

- A 1. evaporation  
2. precipitation  
3. condensation
- B 1. condensation  
2. evaporation  
3. precipitation
- C 1. precipitation  
2. condensation  
3. evaporation
- D 1. evaporation  
2. condensation  
3. precipitation

27 Which list contains **only** abiotic factors?

- A water temperature, amount of sunlight, and soil type
- B density of predators, water depth, and types of parasites
- C precipitation amount, number of prey species, and plant types
- D variety of food sources, annual precipitation, and number of decomposers

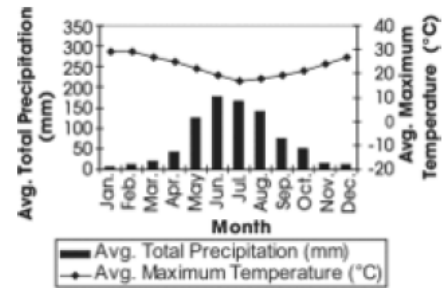
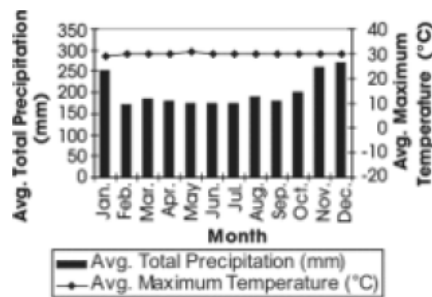
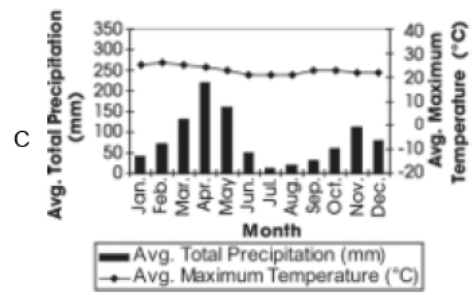
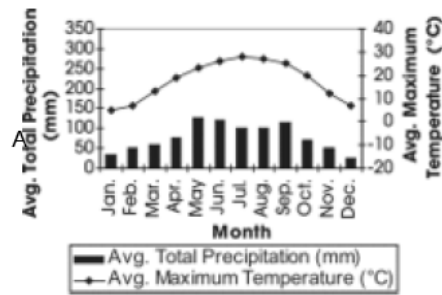
Page 12

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28 Climatographs are often used to represent a location's temperature and precipitation patterns. (Precipitation is represented by the bar graph because it is cumulative.)

Which climatograph most likely represents a tropical rainforest?



29 Which of these produces most of the compounds responsible for causing acid rain?

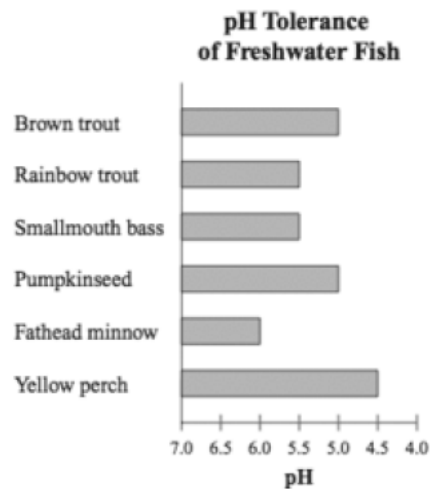
- A Nuclear fission
- B Fossil fuels
- C Solar cells
- D Windmills



30 It is important to protect air quality because

- A storms worsen as air pollution decreases
- B acid rain is caused by air pollution
- C wind currents change when the air is polluted
- D energy produced by the Sun decreases when air is polluted

31 The graph below shows the levels of acidity that different kinds of freshwater fish can tolerate. Low pH values mean the water is more acidic.



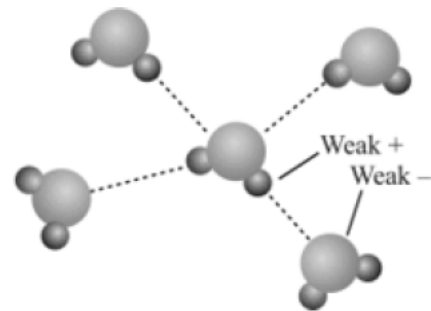
Based on the data, which of the following fish would most likely experience the largest population declines due to acid rain pollution?

- A brown trout
- B smallmouth bass
- C fathead minnow
- D yellow perch

32 Which property of water is shown below?

**Attraction between Water**

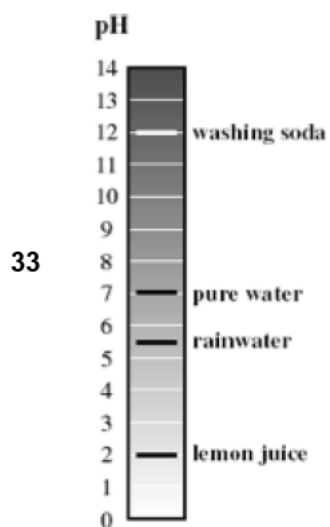
**Molecules**



- A pH
- B polarity
- C adhesion
- D solubility







The strip chart above shows the pH of some common substances. Which substance is basic?

- A** lemon juice
- B** rainwater
- C** pure water
- D** washing soda

**34** A scientist believes that a factory has been dumping acid into a local river. To test this hypothesis, which property of water should the scientist monitor?

- A** pH
- B** density
- C** polarity
- D** temperature



---

Use the information below to answer three questions.

Maryland Natural Resources

Many natural resources are found in Maryland and the surrounding area. Some of these natural resources are renewable and some are nonrenewable. People use both kinds of resources in daily activities. Using natural resources often produces waste products.

---

**35** Recycling centers are where people take materials that may be reused to make new products.

How does recycling paper positively affect the environment?

- A** reduces air pollution
- B** increases soil erosion
- C** reduces trees that are cut
- D** increases habitat destruction

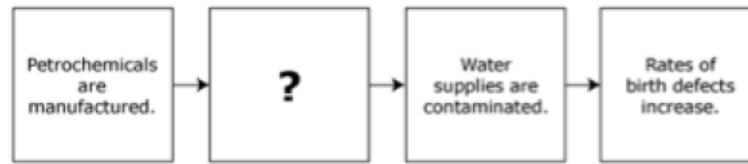
**36** Many states require vehicles to be examined and to meet safety and pollution standards.

What impact might vehicle inspections have on the environment?

- A** The environment will not be polluted.
- B** The environment will become more polluted.
- C** Fewer pollutants will be released by vehicles.
- D** Fewer pollutants will be produced by older vehicles.



37 The flow chart below shows the effects of a type of environmental pollution.



Effects of Petrochemicals

Which **best** completes the flow chart?

- A Anthracite coal is mined.
- B Toxic waste is dumped as a by-product.
- C Organic waste is discarded.
- D Toxic fumes are emitted from vehicles.

38 When trees are removed from a tropical rain forest, other plants and animals are affected.

Which statement identifies another change that will most likely occur when a rain forest habitat is destroyed?

- A Oxygen levels will increase.
- B Carbon dioxide levels will increase.
- C The temperature of Earth will decrease.
- D The air pollution in the atmosphere will decrease.

39 A major reservoir for oxygen is the atmosphere. Which of the following processes adds oxygen to the atmosphere?

- A cellular respiration
- B combustion
- C decomposition
- D photosynthesis

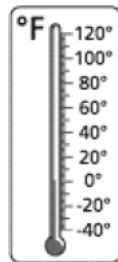
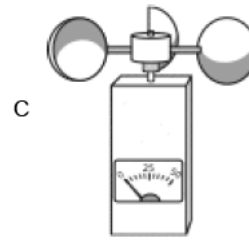
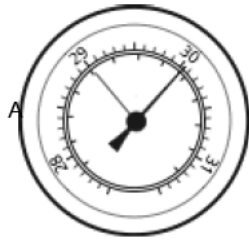
40 A rain gauge is a tool that measures the

- A temperature of rainfall.
- B amount of rainfall.
- C speed of rainfall.
- D time of rainfall.

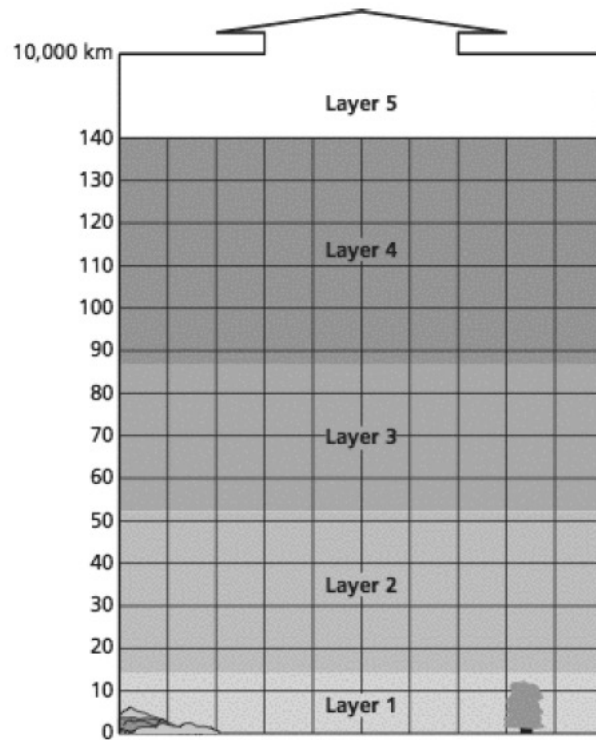


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41 What tool should be used to measure air temperature?



42 The following diagram shows the layers of Earth's atmosphere.



Which of these names the layers of Earth's atmosphere in order, starting with Layer 1?

- A** Troposphere, stratosphere, mesosphere, thermosphere, exosphere
- B** Troposphere, stratosphere, mesosphere, exosphere, thermosphere
- C** Stratosphere, troposphere, thermosphere, mesosphere, exosphere
- D** Stratosphere, mesosphere, troposphere, exosphere, thermosphere



43 Which picture BEST shows Earth's hydrosphere?



- 44 The following tables show the weekly forecasts for several days during the summer and winter in Greenville, Mississippi.

**Forecast During a Week in the Summer**

	High Temperature (°F)	Low Temperature (°F)	Average Humidity	Precipitation (inches)	Average Wind Speed (mph)
Monday	96	73	71%	0.00	13
Tuesday	95	76	69%	0.00	24
Wednesday	95	75	72%	0.00	10
Thursday	94	73	70%	0.12	21

**Forecast During a Week in the Winter**

	High Temperature (°F)	Low Temperature (°F)	Average Humidity	Precipitation (inches)	Average Wind Speed (mph)
Monday	62	34	67%	1.97	26
Tuesday	68	52	86%	0.12	29
Wednesday	52	35	89%	0.19	12
Thursday	47	33	69%	1.23	22

Which statement describes the weather for Greenville, Mississippi?

- A Greater humidity during the summer
- B More precipitation during the winter
- C Higher temperatures during the winter
- D Faster wind speeds during the summer



---

**45** According to scientists, which of the following material categories is thought to be the primary cause for the depletion of the ozone layer?

- A** chlorofluorocarbons
- B** coal-containing sulfur
- C** fossil fuels
- D** hydrocarbons





46 Many scientists think that burning fossil fuels has increased the amount of carbon dioxide in the atmosphere.

What effect would the increase of carbon dioxide most likely have on the planet?

- A a cooler climate
- B a warmer climate
- C lower relative humidity
- D more ozone in the atmosphere

47 One issue caused by ozone depletion is increased

- A acid rain.
- B skin cancer cases.
- C fossil fuel emissions.
- D number of infectious diseases.

48 The Montreal Protocol is an agreement among some countries to decrease and eliminate the use of certain chemicals such as chlorofluorocarbons (CFCs) in aerosol cans.

What is the Montreal Protocol **directly** trying to protect?

- A ozone layer
- B polar ice caps
- C old growth forests
- D endangered species

49 The use of certain chemicals by humans has caused holes to form in the Earth's ozone layer. This allows more ultraviolet (UV) light to reach the oceans. Scientists are concerned that an increase in UV light will start killing microscopic marine algae.

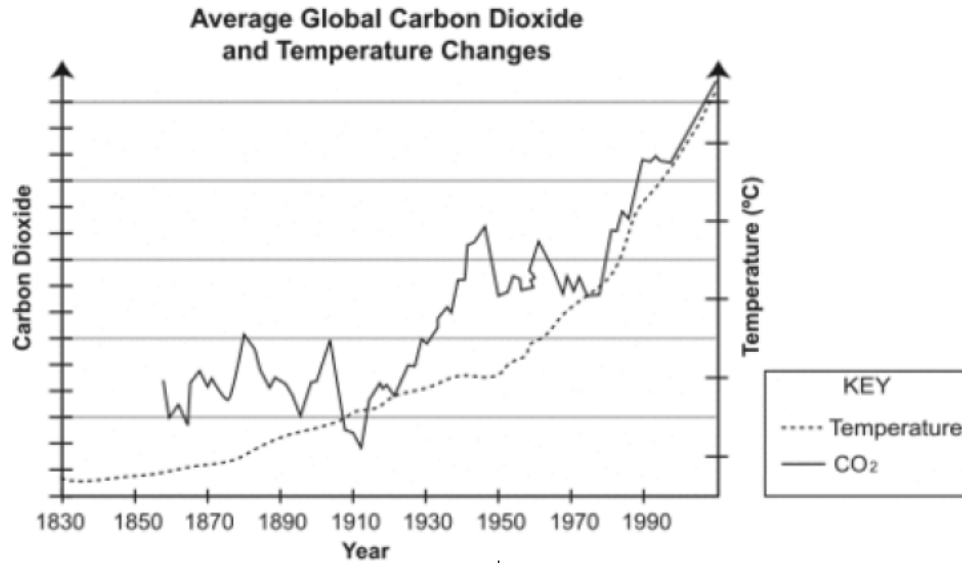
Which of these statements describes how the ocean food web would be affected by a large decrease in microscopic marine algae?

- A There will be fewer marine animals because there will be fewer producers.
- B There will be no change because the algae are very small.
- C There will be more consumers because the UV light kills producers.
- D There will be fewer consumers because the UV light kills decomposers.



## Global Warming

The burning of fossil fuels to heat homes, power factories, and run automobiles is largely responsible for increasing carbon dioxide emissions. Many scientists hypothesize that the increase in these greenhouse gases contributes directly to global warming. The graph below shows average global changes in carbon dioxide and temperature over an extended period of time.



**50** A business claims to be doing “everything possible” to reduce greenhouse gas emissions. Which company practice would cause a consumer to question this claim?

- A** The company vehicles all use diesel fuel.
- B** The building lights are triggered by motion.
- C** The building is powered by geothermal energy.
- D** The company purchases recycled paper products.

**51** Assume the use of fossil fuels continues to increase over the next decade. What prediction are scientists **most likely** to make for carbon dioxide and temperature change?

- A** Carbon dioxide will increase, causing an increase in temperature.
- B** Temperature will increase, causing a decrease in carbon dioxide.
- C** Carbon dioxide will increase, and temperature will remain the same.
- D** Temperature will increase, and carbon dioxide will remain the same.



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**52** The natural greenhouse is a phenomenon that is beneficial as it results in\_\_\_\_\_.

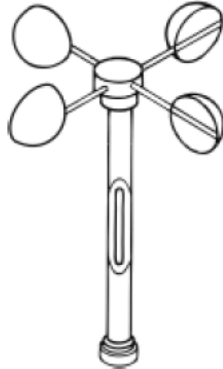
- A** the maintenance of Earth's temperature
- B** a thinning of Earth's atmospheric ozone layer
- C** an increase in the amount of carbon dioxide in Earth's atmosphere
- D** the bending of the rays of sunlight that penetrate Earth's atmosphere



**53** Which property of air does a barometer measure?

- A** speed
  - B** pressure
  - C** humidity
  - D** temperature
- 

**54** The diagram below shows a weather instrument.



Which weather condition is measured by this instrument?

- A** air humidity
- B** air pressure
- C** wind direction
- D** wind speed



## APPENDIX E – Children’s Environmental Attitude and Knowledge Scale

### Children’s Environmental Attitude and Knowledge Scale (CHEAKS)

Frank C. Leeming, William O’Dwyer, and Bruce A. Bracken 1995

*Please indicate how often you have had following experiences by circling the option that best represents you.*

Statement	Very True	Mostly True	Not Sure	Mostly False	Very False
<b>Verbal Commitment</b>					
I would be willing to stop buying some products to save animals’ lives.					
I would not be willing to save energy by using less air conditioning.					
To save water, I would be willing to use less water when I bathe.					
I would not give \$15 of my own money to help the environment.					
I would be willing to ride the bus to more places in order to reduce air pollution.					
I would not be willing to separate family’s trash for recycling.					
I would give \$15 of my own money to help protect wild animals.					
To save energy, I would be willing to use dimmer lights. (1) very true					
To save water, I would be willing to turn off the water while I wash my hands.					
I would go from house to house to pass our environmental information.					
I would be willing to write letters asking people to help reduce pollution.					
I would be willing to go from house to house asking people to recycle.					
<b>Actual Commitment</b>					
I have not written someone about a pollution problem.					
I have talked with my parents about how to help with environmental problems.					
I turn off the water in the sink while I brush my teeth to conserve water.					
To save energy, I turn off lights at home when they are not in use.					
I have asked my parents not to buy products					

made from animal fur.					
I have asked my parents to recycle some of the things we use.					
I have asked others what I can do to help reduce pollution.					
I have often read stories that are mostly about the environment.					
I do not let a water faucet run when it is not necessary.					
I leave the refrigerator open while I decide what to get out.					
I have put up a birdhouse near my house.					
I do not separate things at home for recycling					
<b>Affect</b>					
I am frightened to think people don't care about the environment.					
I get angry about the damage pollution does to the environment.					
It makes me happy when people recycle used bottles, cans, and paper					
I get angry when I think about companies testing products on animals.					
It makes me happy to see people trying to save energy.					
I am not worried about running out of water.					
I do not worry about environmental problems.					
I am not frightened about the effects of pollution on my family.					
I get upset when I think of the things people throw away that could be recycled.					
It makes me sad to see houses being built where animals used to live.					
It frightens me to think how much energy is wasted.					
It upsets me when I see people use too much water.					
<b>Additional Comments:</b>					

## APPENDIX F -Career Interest Survey (STEM-CIS)

### STEM Career Interest Survey (STEM-CIS)

Meredith W. Kier, Margaret Blanchard, Jason Osborne and Jennifer Albert (2013)

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#### Directions:

*Please mark (✓) the answer that best fits you. There are no "right" or "wrong" answers!*

#### Science

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am able to get a good grade in my science class.					
2. I am able to complete my science homework.					
3. I plan to use science in my future career.					
4. I will work hard in my science classes.					
5. If I do well in science classes, it will help me in my future career.					
6. My parents would like it if I choose a science career.					
7. I am interested in careers that use science.					
8. I like my science class.					
9. I have a role model in a science career.					

10. I would feel comfortable talking to people who work in science careers.					
11. I know of someone in my family who uses science in their career.					
12. I am more interested in science since experiencing the STEM career presentations by actual STEM professionals.					
13. I am more interested in science careers since experiencing the STEM career presentations by actual STEM professionals.					

### Math

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am able to get a good grade in my math class.					
2. I am able to complete my math homework.					
3. I plan to use math in my future career.					
4. I will work hard in my math classes.					
5. If I do well in math classes, it will help me in my future					



career.					
6. My parents would like it if I choose a math career.					
7. I am interested in careers that use math.					
8. I like my math class.					
9. I have a role model in a math career.					
10. I would feel comfortable talking to people who work in math careers.					
11. I know someone in my family who uses math in their career.					
12. I am more interested in math since experiencing the STEM career presentations by actual STEM professionals.					
13. I am more interested in math careers since experiencing the STEM career presentations by actual STEM professionals.					

### Technology

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am able to do well in activities that involve technology.					
2. I am able to learn new technologies.					

3. I plan to use technology in my future career.					
4. I will learn about new technologies that will help me with school.					
5. If I learn a lot about technology, I will be able to do lots of different types of careers.					
6. My parents would like it if I choose a technology career.					
7. I like to use technology for class work.					
8. I am interested in careers that use technology.					
9. I have a role model who uses technology in their career.					
10. I would feel comfortable talking to people who work in technology careers.					
11. I know of someone in my family who uses technology in their career.					
12. I am more interested in technology since experiencing the STEM career presentations by actual STEM professionals.					
13. I am more interested in technology careers since experiencing the STEM career presentations by actual STEM professionals.					

## Engineering

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am able to do well in activities that involve engineering.					
2. I am able to complete activities that involve engineering.					
3. I plan to use engineering in my future career.					
4. I will work hard on activities at school that involve engineering.					
5. If I learn a lot about engineering, I will be able to do lots of different types of careers.					
6. My parents would like it if I choose an engineering career.					
7. I am interested in careers that involve engineering.					
8. I like activities that involve engineering.					
9. I have a role model in an engineering career.					
10. I would feel comfortable talking to people who are engineers.					
11. I know of someone in my family who is an engineer.					
12. I am more interested in engineering since experiencing the STEM career presentations by					

actual STEM professionals.					
13. I am more interested in engineering careers since experiencing the STEM career presentations by actual STEM professionals.					

***Optional Demographic Questions:***

Gender: Male or Female

Age: \_\_\_\_\_

Ethnicity: a. Hispanic or Latino

b. Not Hispanic or Latino

Race: a. American Indian or Alaska Native

b. Asian

c. Black or African American

d. Native Hawaiian or Other Pacific Islander

e. White

## APPENDIX G – Kolb’s Model of Experiential Learning Instruments

### Experiential Learning: What is expected of the Students

Kolb’s Learning Style	What activity should students complete?
Concrete Experience	Perform activity to gain new experience
Reflective Observation	Reflect on experience by completing the following questions in journal: 1. What did you do? 2. What happened? 3. What did you feel, see, hear, taste? 4. What was the most difficult? Least difficult? 5. What problems occurred during the activity?
Abstract Conceptualization	Discuss the activity and how it relates to the real world by examining the following questions: 1. What did you learn from the activity? 2. Why would this activity be important in real life situation? 3. How does what you learned relate to other parts of your life?
Active Experimentation	Based on new knowledge from the experience, the students should create new innovative ways to approach new concrete experiences. 1. In the future, what changes would you apply to the activity? 2. What new knowledge would contribute to the changes within the activity? 3. Did the activity facilitate the creation of new ideas for other activities?

### **Abstract Conceptualization**

Discuss the activity and how it relates to the real world by examining the following questions:

1. What did you learn from the activity?

---

2. Why would this activity be important in real life situation?

---

3. How does what you learned relate to other parts of your life?

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### **Active Experimentation**

Based on new knowledge from the experience, the students should create new innovative ways to approach new concrete experiences. Discuss the following questions:

1. In the future, what changes would you apply to the activity?
2. What new knowledge would contribute to the changes within the activity?
3. Did the activity facilitate the creation of new ideas for other activities?

## Reflective Observation

Reflect on experience by completing the following questions in journal:

1. What did you do?
2. What happened?
3. What did you feel, see, hear, taste?
4. What was the most difficult? Least difficult?
5. What problems occurred during the activity?

## APPENDIX H -GLOBE Workshop Agenda

### GLOBE Workshop

***Hosted By:***  
**Veshell Lewis (GLOBE Trainer and Teacher)**

### Atmosphere/Soil Protocol Agenda

Time	Activity
8:00- 8:15 am  <i>15 min</i>	Breakfast Provided
8:15 am – 8:30 am  <i>15 min</i>	<b>Workshop Welcome</b> <ul style="list-style-type: none"> <li>• Welcome</li> <li>• Overview of GLOBE</li> <li>• Workshop Objectives</li> </ul>
8:30 am – 9:00 am  <i>30 min</i>	<ul style="list-style-type: none"> <li>• Distribution of Teacher’s Kits</li> <li>• Introduction to GLOBE Educational Materials (Teacher’s Guide, GLOBE Science Log)</li> </ul>
9:00 am – 10:00 am  <i>1 hr</i>	<b>Review GLOBE Protocols</b> <ul style="list-style-type: none"> <li>• Atmosphere Protocol: Current Temperature</li> <li>• Atmosphere Protocol: Surface Temperature</li> <li>• Atmosphere Protocol: Precipitation</li> <li>• Atmosphere Protocol: Clouds</li> <li>• Atmosphere Protocol: Relative Humidity</li> <li>• Soil Protocol: Soil pH</li> <li>• Soil Protocol: SMAP (Soil Moisture Measurement Protocol)</li> </ul>
10:00 – 11:00  <i>1 hr</i>	<ul style="list-style-type: none"> <li>• <b>Review of Research Assessment Instruments</b> <ol style="list-style-type: none"> <li>1. Environmental Knowledge Assessment</li> <li>2. Critical Thinking Test</li> <li>3. Attitude Towards the Environment Survey</li> <li>4. Career Aspirations Survey</li> </ol> </li> </ul>
11:00 am – 11:15 am  <i>15 min</i>	<ul style="list-style-type: none"> <li>• Classroom observations and check list</li> </ul>
11:15 am – 11:30 pm	<b>Wrap-up</b>



## APPENDIX I – GLOBE Protocol Checklist

### GLOBE Protocol Checklist

Teacher:

School:

Date:

GLOBE Protocols	Completion Yes/No	Notes
<b>Precipitation</b>		
<b>Rain Gauge (Taking accurate rainfall measurements)</b>		
read scale at eye level	<input type="checkbox"/>	<input type="checkbox"/>
read scale from bottom of meniscus	<input type="checkbox"/>	<input type="checkbox"/>
record amount of daily rainfall (mm)	<input type="checkbox"/>	<input type="checkbox"/>
record date and time of day (UT)	<input type="checkbox"/>	<input type="checkbox"/>
record # of days rain has accumulated in tube	<input type="checkbox"/>	<input type="checkbox"/>
Empty and reassemble the rainfall tube	<input type="checkbox"/>	<input type="checkbox"/>
empty water into clean tube; save for pH	<input type="checkbox"/>	<input type="checkbox"/>
Invert tube; allow it to drain completely	<input type="checkbox"/>	<input type="checkbox"/>
remove debris from empty tube	<input type="checkbox"/>	<input type="checkbox"/>
remount rain gauge; level top of gauge	<input type="checkbox"/>	<input type="checkbox"/>
<b>Rain Water pH</b>		
Submerge indicator paper for 1+ minutes	<input type="checkbox"/>	<input type="checkbox"/>
Remove and compare to indicator color chart	<input type="checkbox"/>	<input type="checkbox"/>
Identify pH; record results	<input type="checkbox"/>	<input type="checkbox"/>
<b>Clouds</b>		
<b>Cloud</b>		
Viewed the sky in every direction (above 14 degrees).	<input type="checkbox"/>	<input type="checkbox"/>
Look Up to observe sky color, reporting the shade that most closely matches your sky.	<input type="checkbox"/>	<input type="checkbox"/>
Look Across to observe sky visibility.	<input type="checkbox"/>	<input type="checkbox"/>
Identify the types of clouds that you see using the GLOBE Cloud Chart	<input type="checkbox"/>	<input type="checkbox"/>
Record the number of each type of contrails you see.	<input type="checkbox"/>	<input type="checkbox"/>
<b>Temperature</b>		
<b>Air Temperature (Taking accurate temperature readings)</b>		
Read thermometer at eye level	<input type="checkbox"/>	<input type="checkbox"/>
Read temperature from base of indicators	<input type="checkbox"/>	<input type="checkbox"/>
Record current temperature	<input type="checkbox"/>	<input type="checkbox"/>
Record date and time	<input type="checkbox"/>	<input type="checkbox"/>
If no measurement for previous day, record only current temperature	<input type="checkbox"/>	<input type="checkbox"/>
<b>Surface Temperature</b>		
Hold the Infrared thermometer (IRT) straight down at the ground.	<input type="checkbox"/>	<input type="checkbox"/>
Press and release the recording button.	<input type="checkbox"/>	<input type="checkbox"/>
Read and record the surface temperature from the digital display	<input type="checkbox"/>	<input type="checkbox"/>
<b>Humidity:</b>		
Place the hygrometer in the instrument shelter.	<input type="checkbox"/>	<input type="checkbox"/>
After at least 30 minutes, read the relative humidity, and note the instrument used.	<input type="checkbox"/>	<input type="checkbox"/>
Return the hygrometer to the classroom, and store it in a dry place	<input type="checkbox"/>	<input type="checkbox"/>

## Experiential Activity Checklist

Teacher:

School:

Date:

	Completion	Notes
GLOBE Protocol:	Yes/No	
<b>Concrete Experience</b>		
Students perform activity to gain new experience	<input type="checkbox"/>	<input type="checkbox"/>
<b>Reflective Observation</b>		
Students reflect on experience by completing journal activity	<input type="checkbox"/>	<input type="checkbox"/>
<b>Abstract Conceptualization</b>		
Students discuss the activity and how it relates to the real world	<input type="checkbox"/>	<input type="checkbox"/>
<b>Active Experimentation</b>		
Based on new knowledge from the experience, the students create new innovative ways to approach new concrete experiences.	<input type="checkbox"/>	<input type="checkbox"/>

## APPENDIX J – GLOBE Atmosphere Investigation Clouds 1-Day Data Sheet

School/Observer Name: \_\_\_\_\_ Study Site: \_\_\_\_\_

Date (ex. 2017 01 13): Year: \_\_\_\_ Month: \_\_\_\_ Day: \_\_\_\_

Time (ex. 24 Hour Clock: 14 26): Local: Hour \_\_\_\_ Minute \_\_\_\_ Universal: Hour \_\_\_\_ Minute \_\_\_\_

---

### 1. What is in Your Sky?

Total Cloud/Contrail Cover:

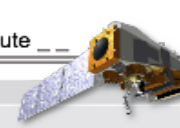
☐ Sky is Obscured →

☐ None (Go to box 2)    ☐ Scattered (25-50%)  
☐ Few (<10%)    ☐ Broken (50-90%)  
☐ Isolated (10-25%)    ☐ Overcast (90-100%)

\*If you can observe sky color or visibility, complete box 2

☐ Fog    ☐ Sand  
☐ Heavy Rain    ☐ Spray    ☐ Haze  
☐ Heavy Snow    ☐ Smoke    ☐ Volcanic Ash  
☐ Blowing Snow    ☐ Dust

**Go to box 6**



---

### 2. Sky Color and Visibility

Color (Look Up): ☐ Cannot Observe    ☐ Deep Blue    ☐ Blue    ☐ Light Blue    ☐ Pale Blue    ☐ Milky

Visibility (Look Across): ☐ Cannot Observe    ☐ Unusually Clear    ☐ Clear    ☐ Somewhat Hazy    ☐ Very Hazy    ☐ Extremely Hazy

---

### 3. High Level Clouds

☐ No High Level Clouds Observed (Go to box 4)    #

Cloud Type:

☐ Contrails (number of): #  
☐ Cirrus  
☐ Cirrocumulus  
☐ Cirrostratus

☐ short-lived  
☐ persistent  
☐ persistent spreading

Cloud Cover:

☐ Few (<10%)  
☐ Isolated (10%-25%)  
☐ Scattered (25%-50%)  
☐ Broken (50%-90%)  
☐ Overcast (>90%)

Visual Opacity:

☐ Opaque  
☐ Translucent  
☐ Transparent

---

### 4. Mid Level Clouds

☐ No Mid Level Clouds Observed (Go to box 5)

Cloud Type:

☐ Altostratus    ☐ Alto cumulus

Cloud Cover:

☐ Few (<10%)  
☐ Isolated (10%-25%)  
☐ Scattered (25%-50%)  
☐ Broken (50%-90%)  
☐ Overcast (>90%)

Visual Opacity:

☐ Opaque  
☐ Translucent  
☐ Transparent

---

### 5. Low Level Clouds

☐ No Low Level Clouds Observed (Go to box 6)

Cloud Type:

☐ Fog    ☐ Stratus  
☐ Nimbostratus    ☐ Cumulus  
☐ Cumulonimbus    ☐ Stratocumulus

Cloud Cover:

☐ Few (<10%)  
☐ Isolated (10%-25%)  
☐ Scattered (25%-50%)  
☐ Broken (50%-90%)  
☐ Overcast (>90%)

Visual Opacity:

☐ Opaque  
☐ Translucent  
☐ Transparent

---

### 6. Surface Conditions

Mandatory:

Snow/Ice	Yes <input type="radio"/> No <input type="radio"/>	Dry Ground	Yes <input type="radio"/> No <input type="radio"/>
Standing Water	Yes <input type="radio"/> No <input type="radio"/>	Leaves on Trees	Yes <input type="radio"/> No <input type="radio"/>
Muddy	Yes <input type="radio"/> No <input type="radio"/>	Raining/Snowing	Yes <input type="radio"/> No <input type="radio"/>


Optional:

You may submit any or all

Temperature: \_\_\_\_ °C

Barometric Pressure: \_\_\_\_ mb

Relative Humidity: \_\_\_\_ %



Comments: \_\_\_\_\_

## APPENDIX K – GLOBE's Integrated 1-Day Data Sheet

# Atmosphere Investigation

## Integrated 1-Day Data Sheet

\* Required Field

School Name: \_\_\_\_\_ Study Site: \_\_\_\_\_

Observer names: \_\_\_\_\_

Date: Year \_\_\_\_\_ Month \_\_\_\_\_ Day \_\_\_\_\_ Universal Time (hour:min): \_\_\_\_\_

### Air Temperature

Current Temperature (°C): \_\_\_\_\_

Maximum Temperature (°C): \_\_\_\_\_ (record only when collected at Local Solar Noon)

Minimum Temperature (°C): \_\_\_\_\_ (record only when collected at Local Solar Noon)

Comments: \_\_\_\_\_

### Barometric Pressure

(Check one): ☐ Sea Level Pressure ☐ Station Pressure

Pressure (mb): \_\_\_\_\_

Comments: \_\_\_\_\_

### Relative Humidity

(Select instrument used):

<input type="checkbox"/> Sling Psychrometer	<input type="checkbox"/> Digital Hygrometer
Dry bulb temperature (°C): _____	Ambient air temperature (°C): _____
Wet bulb temperature (°C): _____	Relative Humidity (%): _____

Comments: \_\_\_\_\_

### Precipitation (record only when collected at Local Solar Noon)

Days of accumulation: \_\_\_\_\_

**Rainfall** select one: ☐ Measurable ☐ Trace ☐ Missing  
(if measurable is selected, complete the following fields)

Accumulation (mm): \_\_\_\_\_

Rain pH Measured With (select one): ☐ pH Paper ☐ pH Meter

pH of Rain: \_\_\_\_\_ (pH measurements only allowed when liquid amount is 3.5 mm or more)

Comments: \_\_\_\_\_

## APPENDIX L – GLOBE Surface Temperature Data Sheet

# Atmosphere Investigation

## Surface Temperature Data Sheet

\* Required Field

School Name: \_\_\_\_\_ Study Site: \_\_\_\_\_

Observer names: \_\_\_\_\_

Date: Year \_\_\_\_\_ Month \_\_\_\_\_ Day \_\_\_\_\_ Universal Time (hour:min): \_\_\_\_\_

### \*Surface Temperature

Site's Overall Surface Condition (Select One): ☐ Wet ☐ Dry ☐ Snow

Sample	Temperature Measurement (°C)	Snow Depth (mm) (*if snow selected above)
1		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
2		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
3		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
4		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
5		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
6		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
7		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
8		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm
9		<input type="checkbox"/> zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measureable (>10mm) _____ mm

Comments: \_\_\_\_\_

\*Sky Conditions (next page):

## APPENDIX M – GLOBE Soil pH Data Sheet

# Soil (Pedosphere) Investigation

### Soil pH Data Sheet

Date of sample collection: \_\_\_\_\_ Study Site: \_\_\_\_\_

Horizon Number: \_\_\_\_\_ Horizon Depth: Top \_\_\_\_\_ cm, Bottom \_\_\_\_\_ cm

**Sample Number 1** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

**Sample Number 2** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

**Sample Number 3** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

Horizon Number: \_\_\_\_\_ Horizon Depth: Top \_\_\_\_\_ cm, Bottom \_\_\_\_\_ cm

**Sample Number 1** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

**Sample Number 2** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

**Sample Number 3** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

Horizon Number: \_\_\_\_\_ Horizon Depth: Top \_\_\_\_\_ cm, Bottom \_\_\_\_\_ cm

**Sample Number 1** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

**Sample Number 2** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

**Sample Number 3** – pH Measurement method (check one): ☐ paper ☐ meter

pH of soil and water mixture \_\_\_\_\_

## APPENDIX N – GLOBE Soil Moisture Data Sheet

# Soil (Pedosphere) Investigation

## Soil Moisture Data Sheet - SMAP Block Pattern

\* Required Field

Study Site: \_\_\_\_\_

Observer names: \_\_\_\_\_

Date samples collected: Date (Year-Month-Day): \_\_\_\_\_

Local Time: \_\_\_\_:\_\_\_\_ (Hours:Min) UT: \_\_\_\_:\_\_\_\_ (Hours:Min)

### Soil State: (check one) \*

☐ Measureable ☐ Frozen ground ☐ Snow on ground ☐ Graupel on ground

☐ Hail on Ground ☐ Frozen water on ground

Note: If Measureable is selected, continue below; all other selections stop here.

### Drying:

Drying Method (oven and temperature range) \_\_\_\_\_ Drying time (hrs:min): \_\_\_\_\_

### Weight Measurements:

Container with sample before drying (a)	Container with sample after drying (b)	Water Weight (c) a - b = xx g (Calculated value by database)	Empty Container Weight (d)	Dry Soil Weight (e) b - d = xx g (Calculated value by database)
Sample <input type="text"/> g	<input type="text"/> g		<input type="text"/> g	
Gravimetric Soil Moisture (f) c / e = xx g/g (Calculated value by database)				

### Container Volume Measurements:

Container volume measurements are required at least once out of every 10 weight measurements, but can be repeated more frequently if desired. Below is your most recently measured Average Sample Volume:

Measure the Initial and Final volume of your measuring cylinder 3 times; container volume and average container volume will be calculated during data entry.

	Initial Volume (V <sub>i</sub> )	Final Volume (V <sub>f</sub> )	Container Volume (V <sub>i</sub> - V <sub>f</sub> ) (Calculated value by database)
Sample 1	<input type="text"/> mL	<input type="text"/> mL	
Sample 2	<input type="text"/> mL	<input type="text"/> mL	
Sample 3	<input type="text"/> mL	<input type="text"/> mL	

Average Container Volume will be calculated during data entry.

Additional observations: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## APPENDIX O – Teacher’s GLOBE Notebook

<b>Teacher's GLOBE Notebook</b>			
Section	GLOBE Protocol	GLOBE Protocol location within GLOBE website	GLOBE Data Sheet
1	Atmosphere Protocol: Current Temperature	<a href="https://www.globe.gov/documents/348614/93d4bb3c-79e3-4255-9fc8-537fc4f870dc">https://www.globe.gov/documents/348614/93d4bb3c-79e3-4255-9fc8-537fc4f870dc</a>	Appendix J
2	Atmosphere Protocol: Surface Temperature	<a href="https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbef2cc5b5">https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbef2cc5b5</a>	Appendix L
3	Atmosphere Protocol: Precipitation	<a href="https://www.globe.gov/documents/348614/97b9939c-7fb5-4b12-8113-59f988781bf5">https://www.globe.gov/documents/348614/97b9939c-7fb5-4b12-8113-59f988781bf5</a>	Appendix K
4	Atmosphere Protocol: Clouds	<a href="https://www.globe.gov/documents/348614/7b79ce82-ebd6-4382-9283-181a412f063f">https://www.globe.gov/documents/348614/7b79ce82-ebd6-4382-9283-181a412f063f</a>	Appendix J
5	Atmosphere Protocol: Relative Humidity	<a href="https://www.globe.gov/documents/348614/89f8c44d-4a99-494b-ba81-1853b80710b4">https://www.globe.gov/documents/348614/89f8c44d-4a99-494b-ba81-1853b80710b4</a>	Appendix J
6	Soil Protocol: Soil pH	<a href="https://www.globe.gov/documents/352961/782a668b-cecb-4801-ad80-db32a701eb58">https://www.globe.gov/documents/352961/782a668b-cecb-4801-ad80-db32a701eb58</a>	Appendix M
7	Soil Protocol: SMAP (Soil Moisture Measurement Protocol)	<a href="https://www.globe.gov/documents/352961/bd487244-d864-41bd-965a-61743033c29b">https://www.globe.gov/documents/352961/bd487244-d864-41bd-965a-61743033c29b</a>	Appendix N



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